Electrical Review

VOL. 26. No. 7. WEEKLY. NEW YORK, WEDNESDAY, FEBRUARY 13, 1895

VIEWS, NEWS AND INTERVIEWS.

"A friend of mine invented a very ingenious gas appliance and wanted to test it in my office," remarked a Wall street broker. "I discovered that there was no gas in my building and we had to inquire in buildings over two blocks down Wall street before we found a gas burner in working order. The incandescent lamp has made great progress, surely."

Mr. Nikola Tesla is generally regarded as an unusually modest man, and one who doesn't go in for ostentatious display. This was exemplified at the time the New York *World* printed an interview with him, written by Arthur Brisbane and accompanied by that truly marvelous picture of Tesla, showing him standing erect with lightning flashes glancing out from every portion of his body. Mr. Tesla had gone to a well-known health resort for a brief vacation a few days prior to the publication of the interview. He had been at the hotel just long enough to make a few acquaintances, and to become pretty well known himself. On the Sunday that the interview was published, the papers containing it reached the hotel at 10 o'clock. Mr. Tesla, in walking about the hotel lobby, observed many people who glanced at a paper in their hands, then looked up at him with an expression of awe, and finally put their heads together and discussed something in whispers. He finally discovered the cause to be that wonderful picture. At 11 o'clock Sunday morning Mr. Tesla was on the first train bound for New York.

The telephonic communication between Berlin and Vienna, which was opened on December 1, has not met with expectations. The sounds are almost inaudible and Vienna papers claim to be able to prove that the trouble lies in the defective instruments used in Berlin.

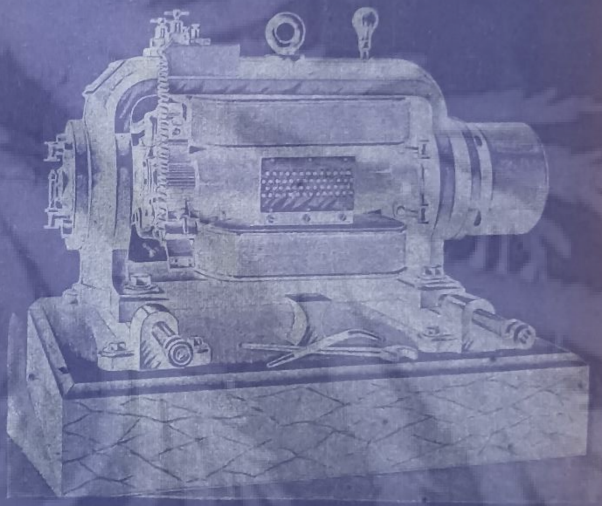
At a recent meeting of the German Electro-Chemical Society, Mr. W

instead of platinum. The co-efficients of expansion by heat of aluminium and glass being very different, special means have to be adopted to secure a tight joint. The plan adopted is as follows: A wire of aluminium is placed in a glass tube and heated until both it and the glass fuse. The aluminium core and its glass jacket thus produced are allowed to cool, when the latter cracks, but this is of no importance, as the object of this jacket is simply to prevent the aluminium melting when it is being soldered on to the thick envelope which is to form the base of the lamp. This having been done and the filament fixed, the bulbs are exhausted, a drop of a strong solution of mercuric chloride having been previously placed on the outer ends of the leading-in wires. As the vacuum is formed in the bulb, this solution is drawn in past the aluminium wires. These latter then first become amalgamated and then oxidized and the alumina thus formed is said to lute up the wires perfectly air-tight.

In response to resolution the railroad commission reports the increase of capital stock by railroads in New York State since 1883. The total

The Lindner Dynamo.

The illustration presented herewith is from London *Industries and Iron* and shows the Lindner dynamo, made by the Elektro-Mekaniska Aktiebolage Norden, of Stockholm, Sweden. This machine embodies several differences in design from the usual dynamo type. It will be seen that there are no special brackets, etc., for supporting the bearings, which are supported in cylindrical openings in the frame itself. The whole of the iron in the frame, therefore, is utilized to form the magnetic system, thus performing a two-fold duty. The lubrication is entirely automatic, and is effected by a device which allows oil to flow from receivers in the body of the cylinder in which the bearings are fixed, and the same oil is continually used until its lubricating properties are exhausted. The quantity and quality of the oil can be inspected at any time by means of gauge glasses, and renewal is usually required only once a fortnight. These dynamos are made either series, shunt or compound wound. It is claimed that there is no sparking at the commutator, and that the brushes require practically no shifting for any load.



The Lindner Dynamo.

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TESLA'S LABORATORY BURNED.

THE DISTINGUISHED INVENTOR'S HEAVY LOSS BY FIRE OF APPARATUS AND RECORDS.

By a fire which almost completely destroyed the six-story and basement building at 33 and 35 South Fifth avenue, New York city, March 13, Nikola Tesla, the electrician, lost all of the apparatus with which he has been carrying on his professional experiments. Mr. Tesla occupied the entire fourth floor. When the floor gave way his apparatus fell to the second floor, where it remained in an unrecognizable ruin. It was not insured.

Mr. Tesla was naturally considerably affected by this sudden and most disastrous loss, but with true grit at once began preparations to resume his work elsewhere. In an interview he says :

I am congratulating myself all the time it is no worse. I begin all over again, but I have the knowledge and experience of what has gone before, and fortunately I was able to show with completed apparatus that my ideas and theories are correct. Had the fire occurred a few months ago, I should have been robbed of the opportunity of many highly successful demonstrations. Take my oscillator, for example, that combines the steam engine and dynamo. Last Fall, for example, I had there a gathering of medical and other professional men—perhaps 200—and they all saw the machine running, lighting up my laboratory with plenty of lights and furnishing current for a series of novel experiments. The machine is gone. But suppose the fire had happened

fected machine, but which, of cours suggests many new lines of thoug every day. Another was improve methods of electric lighting. A other was the transmission of intell gence any distance without wires. fourth, which is an ever present prob lem for every thinking electricia touches the nature of electricity Each of these questions and man others I shall follow up, and someho I cannot help feeling that this dis aster will sharpen my intuition as t the best lines of work, so that goo will come out of evil. With so muc on my mind and hands I need no excuse myself for being brief wit you. I have been overwhelmed wit generosity and sympathy this week and feel the kindness deeply, even i I can make no response. But I mus carve my way through or over the mountain suddenly planted in fron of me, and so you see me preoccupied. I am glad to add to-day that by las reports from the scene of the fir some of the debris is in better shape than I dared hope, and I may yet see some valuable salvage. But my men are meantime busy as though none of the old were left.

A Swiss Electric Railway Project.

Swiss electrical engineers seem to be bent on showing to the world what feats can be accomplished with electric motors. Witness the latest project of an Alpean electrical railway proposed by La Compagnie de l'Industrie Electrique of Geneva. It is

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Fall, for example, I had there a gathering of medical and other professional men—perhaps 200—and they all saw the machine running, lighting up my laboratory with plenty of lights and furnishing current for a series of novel experiments. The machine is gone. But suppose the fire had happened before that or before others had seen it running? My statements about it would not have been half so convincing. Everything is destroyed—practically all—although, of course, where some of it has passed into commercial operation the interest in that part was of an historic and personal nature. I had a cabinet containing many of the earlier inventions, over which I have brooded and worked days and nights. To-day the ideas there embodied are utilized in the big 5,000 horse-power generators at Niagara and in kindred motors in a great many parts of the world; but I prized the old models and trial apparatus, and would not have taken any money for them. Some of them were shown in the Electricity building at the World's Fair, where also some of the new principles I have discovered were illustrated by operative devices. These devices I had in my laboratory, and they have gone down in the wreck, too. Moreover, I had there some records, books and papers, such as every industrious experimenter is likely to get around him in time, and they have vanished. Happily, a good deal of my work has appeared in book form now, or in the technical journals, and that much is secure. The rest, he added, with just a little note of sadness in his voice, I shall try to jot down as soon as I can get time from more pressing matters. You know an inventor while making experiments often gets a few spare minutes between whiles, and I had been employing some of these spells lately in getting my data in better order. Part of that work has gone also.

I was engaged on four main lines of work and investigation. One of these was the oscillator, which I cannot but regard as a practically per-

FIG. 2.—INTERIOR
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delen, on the Riffel Alp, it will
towards Mount Riffel, and gain
Gornergrat at an altitude of 10,
feet above the sea level.

The necessary motive power i
be derived from four rivulets,
the Findelenbach, Toeschbach, Zm
bach and Fürggbach. It is estima
that 600 horse-power is needed

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fected machine, but which, of course, suggests many new lines of thought every day. Another was improved methods of electric lighting. Another was the transmission of intelligence any distance without wires. A fourth, which is an ever present problem for every thinking electrician, touches the nature of electricity. Each of these questions and many others I shall follow up, and somehow I cannot help feeling that this disaster will sharpen my intuition as to the best lines of work, so that good will come out of evil. With so much on my mind and hands I need not excuse myself for being brief with you. I have been overwhelmed with generosity and sympathy this week, and feel the kindness deeply, even if I can make no response. But I must carve my way through or over the mountain suddenly planted in front of me, and so you see me preoccupied. I am glad to add to-day that by last reports from the scene of the fire some of the debris is in better shape than I dared hope, and I may yet see some valuable salvage. But my men are meantime busy as though none of the old were left.

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Bearing this in mind, and backed by experience and the sound common sense characteristic of the American business man, it seems there is little call for lamentation over present prospects or doubts as to the future.

NIKOLA TESLA.

Tesla's loss by fire, while a serious one, has not prostrated the talented inventor, as the accounts in the daily press imply. Instead he goes to work with renewed vigor, replying to a friend, who suggested that he take a long rest before starting in again, that "I might have followed your advice and taken a rest if this had not occurred, but now I feel that it is about time to stop idling." Tesla never was an idler, and if he works any harder now than before, he will have to find the way to live without stopping to eat or sleep. The kindly tone of the great dailies in speaking of the young inventor's loss is particularly noticeable. We do not remember ever having seen a higher compliment paid anyone than the following from the *Sun* of this city, evidently by Mr. Chas. A. Dana:

> The destruction of Nikola Tesla's workshop, with its wonderful contents, is something more than a private calamity. It is a misfortune to the whole world. It is not in any degree an exaggeration to say that the men living at this time who are more important to the human race than this young gentleman can be counted on the fingers of one hand; perhaps on the thumb of one hand.

The ELECTRICAL REVIEW extends to Mr. Tesla its regrets over his most exasperating loss, but with everyone else interested in scientific progress is glad to note his resolution to at once take up his work so near completion. May health and strength and greater success and honor be his!

April 3, 1895

NIKOLA TESLA'S LOST APPARATUS

ILLUSTRATIONS AND DESCRIPTIONS OF SOME OF THE INVENTOR'S DEVICES DESTROYED BY FIRE—HIS GOOD FORTUNE IN HAVING HAD PHOTOGRAPHS MADE OF THIS APPARATUS MORE THAN A YEAR AGO—THE "OSCILLATOR" AND ITS WONDERFUL EFFICIENCY.

Nikola Tesla some time since established his right to be known as the most promising electrical inventor of to-day. When on March 13 last his laboratory, his workshop and all its contents, and most of his important records were totally destroyed by fire, the loss was felt by every one familiar with recent electrical developments.

Tesla, although an extremely modest man, is very widely known through his achievements in pure currents. His first public lecture was based on these discoveries.

Since Tesla's discovery of the "rotating magnetic field" the long-distance transmission of alternating current from Niagara Falls has become possible. The basic idea of this discovery is to produce a circularly shifting magnetism instead of the well-known phenomenon of magnetism in a fixed position.

To the lay mind the most wonderful of all Tesla's experiments was the lighting of electric lamps or empty glass bulbs in free space, without any connection with the wires or generating apparatus. The light from these Tesla tubes is so intense that photographs taken by their illumination have been made with exposures of eight to 10 minutes.

again the labor of years in the hope of reconstructing what had been totally wiped out. He is now busily engaged at this herculean task.

In view of the fact that Mr. Tesla's most important records were burned, it is extremely fortunate that the persuasions of Mr. Thomas Commerford Martin resulted in securing photographs of a number of pieces of apparatus which Mr. Tesla had developed and constructed more than a year ago. The illustrations which accompany this article were made from the photographs referred to. The half-tone plates were engraved at the time the photographs were taken, another fortunate circumstance, as the original prints were burned with everything else the Tesla laboratory contained.

Naturally, Mr. Tesla does not wish to have complete technical evidence

FIG. 1.—THE TESLA OSCILLATOR SHOWN AT CHICAGO IN 1893.

FIG. 2.—A SIMILAR FORM OF OSCILLATOR.

Electrical Review (N.Y.) April 3, 1895

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FIG. 1.—THE TESLA OSCILLATOR SHOWN AT CHICAGO IN 1893.

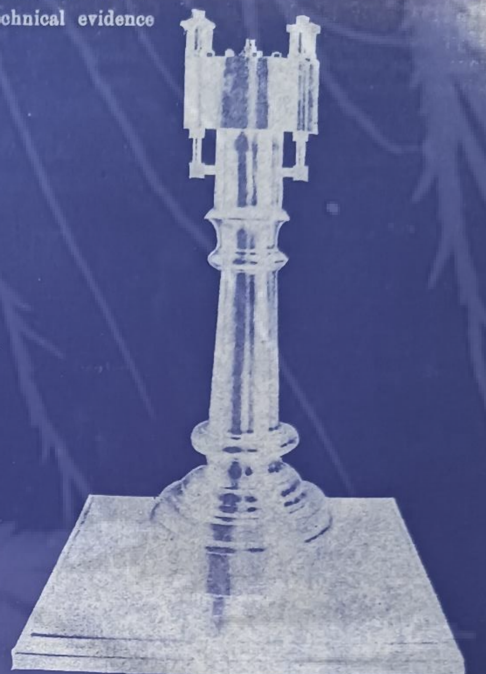

FIG. 2.—A SIMILAR FORM OF OSCILLATOR.

electrical science and through the many articles that have been written about him and his work by lay and technical writers. The loss which he recently sustained was a most serious one and called forth expressions of sympathy from every side. It resulted in his receiving one of the highest compliments ever paid to any man. This was from the pen of Charles A. Dana, editor of the New York *Sun*, and a warm admirer of Tesla. Mr. Dana wrote as follows:

> The destruction of Nikola Tesla's workshop, with its wonderful contents, is something more than a private calamity. It is a misfortune to the whole world. It is not in any degree an exaggeration to say that the men living at this time who are more important to the human race than this young gentleman can be counted on the fingers of one hand; perhaps on the thumb of one hand.

Immediately following the fire Mr. Tesla, instead of being prostrated by his misfortune, as reported in several daily newspapers, secured new quarters in which he began all over

Naturally, Mr. Tesla does not wish to have complete technical evidence of his work published abroad while he is in his present crippled condition, yet it is by his permission that these particulars are given here.

In the course of lectures, all too few in number, Mr. Tesla has at different times demonstrated before technical societies in this country and abroad a number of experiments wonderful in themselves and yet puny in comparison with the deep work of which they were but a feeble outgrowth. It has come to be pretty generally understood that the principal objects of Mr. Tesla's labors were the more efficient production of light, heat and power by electricity and the transmission of energy over long distances. His name is especially associated with the discovery of new phenomena resulting from his researches into the qualities and effects of high potential and high frequency

The wide field for improvement open to Mr. Tesla in his efforts to discover more efficient means of generating electrical energy may be better appreciated when it is stated that actual tests have shown that the energy manifesting itself as light in an incandescent lamp is less than five per cent of that received as current. The other 95 per cent is lost between the coal pile and the lamp. An important step in Mr. Tesla's labors to reduce this tremendous loss was the invention of his "oscillator." He reasoned that if large losses occurred in the steam engine and other large losses in the dynamo, it would minimize the combined losses if both machines were blended in one. And in the crudest terms this is what an oscillator is—an engine-dynamo.

In generating current by a revolving armature there is always some part of the wire winding which is doing no work, just as in the steam engine the steam cylinder and its

April 3, 1895

piston are the only parts doing any work, all the other complex mechanism being used for control or regulation. In brief and popular terms, the Tesla oscillator consists of a bed-plate, in the middle of which is located

FIG. 3.—ANOTHER TYPE OF TESLA OSCILLATOR.

a steam chest. On each side of the steam chest is an electro-magnetic system consisting of field coils, between which the armatures move.

Two pistons are worked by the steam entering the chest. In one case steam at 350 pounds pressure is used, although as low as 80 pounds is used in other oscillators. At the ends of the pistons are the armature coils, which are thrust in and out of the magnetic fields with a reciprocating motion, thus generating current.

Here, then, is a steam engine stripped of every inefficient complication, and at the same time it is an electrical generator in which every part is doing steady work. The oscillator, and one that was entirely practical and successful, had been used for many months in Tesla's laboratory. It was used to light the rooms with incandescent lamps and also furnished current for four arc lamps, for motors, for experiments with the high frequency apparatus and for other investigations. Many visitors to the laboratory have witnessed this oscillator in successful operation.

The oscillator which Mr. Tesla used in his lecture before the International Electrical Congress, during the World's Fair at Chicago, in August, 1893, is the only one that has ever been exhibited in public. This is shown in the accompanying illustration, Fig. 1. For convenience, compressed air instead of steam was used to operate this oscillator during Mr. Tesla's lecture. The machine consists of an engine mounted on an ornamental column, on top of which is a generator much [illegible] in Fig. [illegible]

at a constant temperature by any usual means. The isochronism is perfect because the frictional losses are infinitesimally small compared with the enormous elastic force.

Another quite distinct type is illustrated in Fig. 3. On a stand with a dynamo of somewhat unusual form is mounted a small oscillator. The dynamo includes a circular field magnet in which circular coils are arranged to move on each side. An arbor directly connected to the small engine carries the coils, and currents are produced by vibrating the coils within the field of the magnet. Mr. Tesla says that in this form there is absolutely no useless wire. All of it is within the field and all is equally active.

An oscillator of more advanced form, operated by steam and freely used for laboratory purposes, is shown in Fig. 4. This extremely small machine had a capacity of 12 incandescent globes. [illegible] combination was [illegible] of a [illegible] oscillator and a

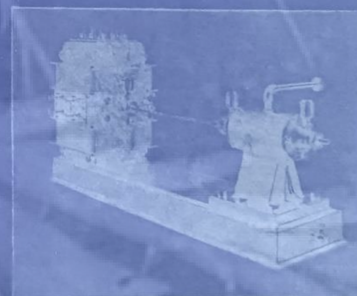

FIG. 4.—OSCILLATOR USED FOR LABORATORY PURPOSES.

used by Mr. Tesla in his demonstrations is illustrated in Fig. 6. Novel features were exemplified by the use of several of the instruments shown. As an example, the magnets in A served to make clear the principle of the preponderance of one impulse over the other in the current produced by the oscillator and creating virtually the effect of a direct or continuous current. A magnet which was vibrated is shown in R. The copper disk D was arranged to rotate freely in bearings. When the disk was held between the poles, that is, in the field of the vibrating ring magnet, it was rotated in one direction. This showed that the currents distributed in the disk were asymmetrical, or in other words, they were preponderating in one direction.

The constancy or invariability of the speed of the oscillator was illustrated by the use of the little motor shown at C in Fig. 6. Another little motor with clockwork attached, shown in G, was used to count the revolutions of the oscillator. Both of these little motors were driven from one circuit, the difference of phase being obtained by artificial means. E was a little generator com-

Electrical Review (N.Y.) June 5, 1895

are to be men who will especially look after the development of the company along its present lines of policy. B.

Monday, June 3, 1895.

The Burning of Tesla's Laboratory.

Now that a little time has elapsed since the disaster which overwhelmed Nikola Tesla's laboratory, it is possible to sum up the significance of the event. Our sympathies have been with this unfortunate physicist from the first, and for good reasons. But the average newspaper man, who, by the way, was mostly extravagant with his commisseration, would probably hesitate to venture upon an answer were he asked to explain definitely what he was grieving about. The thing was terribly overdone at the time it happened, and, in illustration of this, we believe it to be a fact that one vivid young lady of the transatlantic press, in her anxiety to be instructive as well as "alive" in her descriptions, went so far as to depict herself undergoing a brilliant electrical ordeal, that is possible only with the body *in puris naturalibus!* For Tesla's future we have no fear. He is young and indomitable. It took Thomas Carlyle four weeks to quiet his mind after that miserable accident in which John Stuart Mill was concerned, which entailed the destruction of the first volume of the unprinted "French Revolution." But, in spite of sensational reports, we know it to be a fact that Tesla was at work again with clenched determination while the ashes of his hopes are still hot. No! The loss falls least heavily upon the loser. Like many another tireless experimenter, he hoped to give the scientific world the report of his failures as well as of his discoveries; he had not counted upon the casual distruction of his memorabilia and apparatus by fire. The loss falls most heavily upon those scientists who are at work upon the phenomena of high-frequency currents, of insulation, induction, impedance, and resonance, and the problems of obtaining cheap electricity by means of oscillators. In time, Tesla will doubtless reproduce all that was of value in those unfortunate

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The way the New York Edison Illuminating bonds were snapped up

Jan 25, 1899

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[UNITED STATES.]
RK ROW,
NEW YORK.
25, 1899.
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but to a residence in the same block and on the same side of the street. The goods were held one week by the express company and then delivered to the right number in a condition which could give aromatic points to the embalmed beef discovered by General Miles in Cuba and Porto Rico. We should think a company of the caliber of the Adams Express would have men in charge of its city offices intelligent enough to look at one of several city or telephone directories or make some sensible effort to deliver goods promptly.

The general public in and around New York city is just as much as ever, if not more, interested in electrical progress. Bearing this in mind, it seems to us that the National Electric Light Association, as a prominent and influential organization with which the people are familiar, and the Electrical Exhibition Company, which proposes to hold an electrical exposition in the Madison Square Garden next Spring, should combine their forces and influence to produce the very best possible setting forth of all that is latest and best in electrical development. It is to be hoped that electrical manufacturers will do all in their power to make the forthcoming exhibition a representative and instructive one.

Mr. Russel Sage was quoted last week as denying the published report saying that President Gould and Vice-President Gallaway are opposing the substitution of electricity for steam-power on the Manhattan Railway of New York city while he was advocating the change. Mr. Sage denied that there was any friction, and stated that all the gentlemen named were working in harmony. Mr. Sage also intimated that he was

THE END OF KEELY.

Beginning probably with the celebrated "Mississippi scheme" of John Law about 1718, the world has, in the last two centuries, submitted to some gigantic frauds and the people have put their money on the more or less masterly shell-games by millions. The bubbles have burst, and generally within a comparatively short space of time. But it remained for Keely to break the great record, for he fooled his dupes for almost a quarter of a century, and longer, for some of them really appear yet to believe in his motor.

It is a wonderful record, all the more so that the fraud was perpetrated on and really believed in by many men of superior intelligence, and by some who had more or less scientific and mechanical training. In the old palmy days of Keely, many a man of cautious and mature judgment, on witnessing the so-called manifestations of the "etheric force" of the great charlatan, would shake his head in perplexity and admit he was at a loss to controvert the apparent facts. And often such a man would ponder over the possibilities of such a new engine and wind up his cogitations by drawing his check and buying Keely stock. The fraud was too attractive for him and for many others.

Keely had a motor, however, and it was for years in successful operation; the world saw it, applauded, came forward and became itself the medium of the successful operation. The records show this. But this successful motor was only adapted for one kind of work, which was the transferring of hard-earned dollars from the pockets of the dupes to that of Keely. In that respect there was a very real Keely motor, but its dear public and unfailingly [illegible] them all snugly into the pocket belonging to the master-hand at the throttle. All the suavity and shrewdness and experience of all the bunco steerers in the country rolled into one could not approach such a success as this extraordinary individual conceived and executed in the teeth of all the experts of the world. Surely, history has no parallel to this. But Keely is dead, his laboratory has been dismantled, and his secret and fraud unearthed. It looks now as if the committee had done its work thoroughly and laid the ghost forever.

The Autotruck Company of New York city, is apparently doing a lively business in the selling of its shares, but who has seen an actual truck anywhere about the city loaded with "ten tons" of merchandise? Who ever will see a truck full of goods to the extent of ten tons tearing along our streets at a rate of ten miles per hour? What street would stand it? But while streets could not stand under such burdens, the public will stand anything in the way of promises. It is a life of hope we live, truly.

The Northwestern Electrical Association held a very successful annual convention at Milwaukee last week. The papers read before the delegates were interesting, and the discussions following were profitable. During the meeting the announcement was made that the Northwestern Electrical Association has a larger membership than any other similar organization in the United States. In view of the fact that the association represents the comparatively smaller central stations within its jurisdiction, this is an encouraging sign of the times. The "big fellows" are rather expected to look out for

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Keely had a motor, however, and it was for years in successful operation; the world saw it, applauded, came forward and became itself the medium of the successful operation. The records show this. But this successful motor was only adapted for one kind of work, which was the transferring of hard-earned dollars from the pockets of the dupes to that of Keely. In that respect there was a very real Keely motor, but its operation was unobserved of all. Lubrication was perfect, not a bearing squeaked. Balance was admirable, not a chatter could be heard. Yet the machine was in motion for years, but its operation was so shrewdly directed and controlled, that it went along for 25 years almost unceasingly, abstracting millions of dollars from the pockets of the

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VOL. 34. No. 2. WEEKLY. NEW YORK, WEDNESDAY, JANUARY 11 189

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VIEWS, NEWS AND INTERVIEWS.

Mrs. Bloomfield Moore, of Philadelphia, died at her residence in London on January 5. For years she had been known as a financial backer of Keely, the motor man, and it is estimated that she gave him, at various times during her acquaintance with him, from $75,000 to $100,000. She took up the study of his theories, and was almost as familiar with them as he was. When Keely's death was announced, Mrs. Moore, who was ill, began to fail, and her friends believe this was largely responsible for her death. Mrs. Moore was the author of numerous papers and essays dealing with Keely's theories. About 10 years ago she endeavored to enlist the sympathies and influence of the ELECTRICAL REVIEW in aid of her friend Keely. When she failed in her attempt, she made a serious proposition to purchase the ELECTRICAL REVIEW outright, with the under standing it would thereafter advocate the Keely cult. Failing also in this, she founded a monthly magazine called the *New Science Review*, which, however, existed only for a few months. Mrs. Moore was the widow of a wealthy paper manufacturer of Philadelphia, and inherited from her husband an estate worth about $6,000,000. The closing years of her life were devoted to endeavors to enlist the sympathies and influence of scientific men in Keely's work. She was about 75 years old at the time of her death.

It is reported that Richard Croker, Jr., a son of the leader of Tammany Hall, has secured a position with the

made of steel and cost £500. It is said that the new diving-bell will revolutionize the pearl-fishing industry.

The Commercial Cable Building in Broad street, New York city, is probably as thoroughly equipped with electric elevators as any other building in the world. The installation is modern and up to date in every respect, including an auxiliary storage battery of considerable size. The elevator service from the passenger's standpoint is, however, unusually bad. It seems a pity that a system can not be put in operation in this handsome building under which the best efficiency of the elevator plant may be obtained. The elevator doors on the various floors are covered with badly printed placards, which of themselves are very unsightly. These cards inform the waiting passenger that certain elevators are express, certain others do not go beyond the tenth floor, etc. For instance, on the nineteenth floor, at

REPAIRING THE LIGHTNING-ROD ON ST. PETER'S, AT ROME.

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(From the London Electrical Review.)

Our readers will be grieved to learn, on the authority of Mrs. Bloomfield Moore, in the *New Science Review*, that Mr. Tesla is in a very awkward position. It is a number of days, says this gifted woman, since Tesla crossed the border line of the circle in which other electricians are working, but he still remains in the interatomic field of research, unmindful of the triple conditions that govern electricity in the relation which it sustains to the first order of the "liminous." This is sad enough, but we have yet to tell the worst. It appears that by reason of Tesla's wicked neglect of Keely's system of resonance he has missed the chance of hobnobbing with electrical phenomena in the sympathetic field, and is standing on a bridge which connects the primary two-thirds of the electric stream—the subdominant current with the dominant. What a fearsome post is his! But the consequences of his folly will still pursue him, and even though he may hook on to the dominant, he will still be subserved to the terrestrial neutral far in the rear of sympathetic union to radiating celestial outreach, the connecting link of which exists in the interluminous. Mrs. Moore says, further, that even in the event of Tesla's salvation, he will not have reached the compound interetheric. If such be the case, we should advise Mr. Tesla to climb down at once from his supradominant hypoluminous outreachment, and no longer seek to attain the interatomic realm, but to content himself with hard pan. The sting of Mrs. Moore is, however, in her—well, our readers will understand. Given a prompt cash settlement, and Keely will plank down all his secrets, and tell us how we may make a 10,000-ton ship float like a gossamer in the Summer breeze. (Our readers will kindly take notice that this last poetic vein is our own, not Mrs. Moore's.) Failing this settlement they will die with Keely. The cosmical law of sympathetic association will then be lost to an ungrateful world, and Keely will rise on his vibratory mediums into the far outreach after a life spent in over-reaching, amongst others, Mrs. Moore.

Electrical Review (NY) Aug 7, 1895

The Tesla Multiphase System.

Mr. Lemuel Bannister, vice-president and general manager of the Westinghouse Electric and Manufacturing Company, of Pittsburgh, is sending the following letter to central stations throughout the country:

In view of the great prominence given to the multiphase motors covered by the patents of Mr. Nikola Tesla, we think it right to direct your attention to the fact that this company claims the exclusive right to manufacture and sell all forms of motors operated by currents of two, three or more phases, and all forms of single-phase motors where a second phase is induced so as to make the same a two-phase induction motor, notably the form used for the operation of fans. Suits are now pending against the Thomson Houston Electric Company (the General Electric Company), the Stanley Manufacturing Company, of Pittsfield, Mass., and numerous suits have been entered against the users of apparatus purchased from the above companies; it being the intention of this company to enforce its exclusive right to manufacture and sell multiphase generators and motors, the two being used in combination as a system, and such system being covered by the patents of Nikola Tesla above referred to. In the first named suits, the General Electric Company has put in its defense, and the court has limited it to October 7, 1895, in which to complete its testimony, so that a hearing may be had in the latter part of this year or the beginning of 1896. We are advised that the defense has been unable to produce a single working device that can in any way take from Mr. Tesla the pioneer character of his inventions.

We have been informed that the two companies named have offered to guarantee the purchaser of infringing apparatus against damage or loss, [...] companies desiring to remodel or to increase their plants to make a full and careful investigation of the Tesla apparatus as installed in our works at East Pittsburgh, and you are invited to come or send a representative, to whom every facility will be given for careful inspection.

The Baltimore Electric Locomotive.

The first high-speed trial of the Baltimore & Ohio Railroad Company's electric locomotive took place in the Belt Line tunnel at Baltimore on September 6. The trial developed a speed of 61 miles an hour on the heavy grade of the tunnel, and the engineers said it was equivalent to 75 miles an hour on a level track. The performance of the locomotive was such that they would not hesitate to run it at that, or even a greater speed, if they had a sufficient stretch of track for the purpose. This locomotive was not designed for fast time, and the result of its latest test is looked upon as an indication of what may be expected from an electric locomotive specially designed for such a purpose. Since August 4 the locomotive has been hauling the entire freight service of the Baltimore & Ohio through the tunnel, and it has been daily ready for operation every hour of the 24. The average speed maintained in hauling heavy freights has been 15 miles an hour.

The British Association.

The sixty-fifth annual meeting of the British Association for the Advancement of Science opened on September 11 at Ipswich, England. Lord Kelvin introduced the new president, Sir Douglas Galton, who

Electrical Review (NY) Sept. 18, 1895

may be had in the latter part of this year or the beginning of 1896. We are advised that the defense has been unable to produce a single working device that can in any way take from Mr. Tesla the pioneer character of his inventions.

We have been informed that the two companies named have offered to guarantee the purchaser of infringing apparatus against damage or loss, but you can well appreciate that it will be impossible for such companies to make good their guarantees to cover *all* losses if the courts enjoin the use of apparatus made in imitation of that covered by Tesla's patents.

We are prepared to furnish multiphase generators and motors for all classes of work, and being the owners of the patents, no contingency can arise by which the purchasers of such apparatus made by us can in any way be interfered with in its continued commercial use.

It is the opinion of those who have given the subject most careful attention, that in the near future a very large proportion of the electric work will be done by the multiphase system, and this, together with the fact that in the main, we believe, men would prefer to purchase property from its rightful owners, has led us to write to you and give you an opportunity to place your orders with this company for such multiphase apparatus as you may desire to use, and thus avoid the risks incident to the purchase of apparatus from unlawful manufacturers.

The adoption by the General Electric Company of the term "Monocyclic" in connection with their use of multiphase apparatus, does not free them from the charge of infringement, but on the contrary makes the case against them stronger, because of the sale of apparatus under misleading terms.

In conclusion we wish to call your attention to the fact that with our system incandescent lights, arc lamps and alternating motors can be operated from the same circuits, and that it will be of especial advantage to

freights has been 15 miles an hour

The British Association.

The sixty-fifth annual meeting the British Association for the A vancement of Science opened September 11 at Ipswich, Englan Lord Kelvin introduced the n president, Sir Douglas Galton, w started in to read a long addre After reading three-quarters of t address Sir Douglas fainted. soon recovered, but Sir John Eva read the rest of the address. Amo those present were Professor Remsen of Johns Hopkins Universi Baltimore, and Dr. Frederick Bed of Cornell University.

Telegraphers are alarmingly su ject to consumption, according to t *British Medical Journal.* Out 100 deaths among all adult males England, 13.8 are due to consumptio out of 100 deaths among the grind in the cutlery trade who are specia subject to the disease, 33.1 are d to it, while the proportion for t telegraph operators is 46.6 in 1 More than half of them die diseases of the respiratory orga against 24 per cent only in all oth occupations.

H. C. Bunner, the editor of *Pu* has written for the October *Scribn* an account of the rise and devel ment of the poster habit in Ameri with a very amusing series of illu trations.

ELEC. REV. (N.Y.) MAR. 11, 1896

very effective working, the inside surface of the wall, where the cathode stream strikes, should appear as if the glass were in a fluid state.

As a cooling medium I have found best to employ jets of cold air. By this means it is possible to operate successfully a bulb with a very thin wall, while the passage of the rays is not materially impeded.

I may state here that the experimenter need not be deterred from using a glass bulb, as I believe the opacity of glass as well as the transparency of aluminum are somewhat exaggerated, inasmuch as I have found that a very thin aluminum sheet throws a marked shadow, while, on the other hand, I have obtained impressions through a thick glass plate.

The above method is valuable not only as a means of obtaining the high vacua desired, but it is still more important, because the phenomena observed throw a light on the results obtained by Lenard and Roentgen.

Though the phenomenon of rarefaction under above conditions admits of different interpretations, the chief interest centers on one of them, to which I adhere—that is, on the actual expulsion of the particles through the walls of the bulb. I have lately observed that the latter commences to act properly upon the sensitive plate only from the point when the exhaustion begins to be noticeable, and the effects produced are the strongest when the process of exhaustion is most rapid, even though the phosphorescence might not appear particularly bright. Evidently, then, the two effects are closely connected, and I am getting more and more convinced that we have to deal with a stream of material particles, which strike the sensitive plate with great velocities. Taking as a basis the estimate of Lord Kelvin on the speed of projected particles in a Crookes' bulb, we arrive easily by the employment of very high potentials to speeds of as much as a hundred kilometres a second. Now, again, the old question arises: Are the particles from the electrode or from the charged surface generally, including the case of an external electrode, machines or induction coils, but by actual projection, the formation of streamers being absolutely prevented by careful static screening.

A peculiar thing about the Roentgen rays is that from low frequency to the highest obtainable there seems to be no difference in the quality of the effects produced, except that they are more intense when the frequency is higher, which is very likely due to the fact that in such case the maximum pressures on the cathode are likewise higher. This is only possible on the assumption that the effects on the sensitive plate are due to projected particles, or else to vibrations far beyond any frequency which we are able to obtain by means of condenser discharges. A powerfully excited bulb is enveloped in a cloud of violet light, extending for more than a foot around it, but outside of this visible phenomenon there is no positive evidence of the existence of waves similar to those of light. On the other hand, the fact that the opacity bears some proportion to the density of the substance speaks strongly for material streams, and the same may be said of the effect discovered by Prof. J. J. Thomson. It is to be hoped that all doubts will shortly be dispelled.

A valuable evidence of the nature of the radiations and progress in the direction of obtaining strong impressions on the plate might be arrived at by perfecting plates especially sensitive to mechanical shock or impact. There are chemicals suitable for this, and the development in this direction may lead to the abandonment of the present plate. Furthermore, if we have to deal with streams of material particles, it seems not impossible to project upon the plate a suitable substance to insure the best chemical action.

With apparatus as I have described, remarkable impressions on the plate are produced. An idea of the intensity of the effects may be gained when I mention that it is easy to obtain shadows with comparatively short exposures at distances of many feet, while at small distances and with thin objects, exposures of a few skeleton in visible, ... clear outline of the abdominal cavity and the location of the lungs, the fur and many other features. Prints of even large birds show the feathers quite distinctly.

Clear shadows of the bones of human limbs are obtained by exposures ranging from a quarter of an hour to an hour, and some plates have shown such an amount of detail that it is almost impossible to believe that we have to deal with shadows only. For instance, a picture of a foot with a shoe on it was taken, and every fold of the leather, trousers, stocking, etc., is visible, while the flesh and bones stand out sharply. Through the body of the experimenter the shadows of small buttons and like objects are quickly obtained, while with an exposure of from one to one and a half hour the ribs, shoulder-bones and the bones of the upper arm appear clearly, as is shown in the annexed print. It is now demonstrated beyond any doubt that small metallic objects or bony or chalky deposits can be infallibly detected in any part of the body.

An outline of the skull is easily obtained with an exposure of 20 to 40 minutes. In one instance an exposure of 40 minutes gave clearly not only the outline, but the cavity of the eye, the chin and cheek and nasal bones, the lower jaw and connections to the upper one, the vertebral column and connections to the skull, the flesh and even the hair. By exposing the head to a powerful radiation strange effects have been noted. For instance, I find that there is a tendency to sleep and the time seems to pass away quickly. There is a general soothing effect, and I have felt a sensation of warmth in the upper part of the head. An assistant independently confirmed the tendency to sleep and a quick lapse of time. Should these remarkable effects be verified by men with keener sense of observation, I shall still more firmly believe in the existence of material streams penetrating the skull. Thus it may be possible by these strange appliances to project a suitable chemical into any part of the body.

Roentgen advanced modestly his results, warning against too much hope. Fortunately his apprehensions were groundless, for, although we have to all appearance to deal with mere shadow projections, the possibilities of the application of his discovery are vast. I am happy to have contributed to the development of the great art he has created.

NIKOLA TESLA.

New York, March 7, 1896.

ELECTRICAL (N.Y.)

bulb has then reached the required degree of rarefaction. The process may be hastened by repeated heating and cooling and by the employment of a small electrode. It should be added that bulbs with external electrodes may be treated in the same way. It may be also of interest to state that under certain conditions, which I am investigating more closely, the pressure of the gas in a vessel may be augmented by electrical means.

I believe that the disintegration of the electrode, which invariably takes place, is connected with a notable diminution of the temperature. From the point on, when the electrode gets cool, the bulb is in a very good condition for producing the Roentgen shadows. Whenever the electrode is equally, if not hotter than the glass, it is a sure indication that the vacuum is not high enough, or else that the electrode is too small. For very effective working, the inside surface of the wall, where the cathode stream strikes, should appear as if the glass were in a fluid state.

As a cooling medium I have found best to employ jets of cold air. By this means it is possible to operate successfully a bulb with a very thin wall, while the passage of the rays is not materially impeded.

I may state here that the experimenter need not be deterred from using a glass bulb, as I believe the opacity of glass as well as the transparency of aluminum are somewhat exaggerated, inasmuch as I have found that a very thin aluminum sheet throws a marked shadow, while, on the other hand, I have obtained impressions through a thick glass plate.

The above method is valuable not only as a means of obtaining the high vacua desired, but it is still more important, because the phenomena observed throw a light on the results obtained by Lenard and Roentgen.

Though the phenomenon of rarefaction under above conditions admits of different interpretations, the chief interest centers on one of them, to which I adhere—that is, on the actual expulsion of the particles through projected through the glass or aluminum walls, or do they merely hit the inner surface and cause particles from the outside of the wall to fly off, acting in a purely mechanical way, as when a row of ivory balls is struck? So far, most of the phenomena indicate that they are projected through the wall of the bulb, of whatever material it may be, and I am seeking for still more conclusive evidence in this direction.

It may not be known that even an ordinary streamer, breaking out suddenly and under great pressure from the terminal of a disruptive coil, passes through a thick glass plate as though the latter were not present. Unquestionably, with such coils pressures are practicable which will project the particles in straight lines even under atmospheric pressure. I have obtained distinct impressions in free air, not by streamers, as some experimenters have done, using static machines or induction coils, but by actual projection, the formation of streamers being absolutely prevented by careful static screening.

A peculiar thing about the Roentgen rays is that from low frequency to the highest obtainable there seems to be no difference in the quality of the effects produced, except that they are more intense when the frequency is higher, which is very likely due to the fact that in such case the maximum pressures on the cathode are likewise higher. This is only possible on the assumption that the effects on the sensitive plate are due to projected particles, or else to vibrations far beyond any frequency which we are able to obtain by means of condenser discharges. A powerfully excited bulb is enveloped in a cloud of violet light, extending for more than a foot around it, but outside of this visible phenomenon there is no positive evidence of the existence of waves similar to those of light. On the other hand, the fact that the opacity bears some proportion to the density of the substance speaks strongly for material streams, and the same may be said of the effect discovered by Prof. J. J. Thomson seconds are practicable. The annexed print is a shadow of a copper wire projected at a distance of 11 feet through a wooden cover over the sensitive plate. This was the first shadow taken with my improved apparatus in my laboratory. A similar impression was obtained through the body of the experimenter, a plate of glass, nearly three-sixteenths of an inch thick, a thickness of wood of fully two inches and through a distance of about four feet. I may remark, however, that when these impressions were taken, my apparatus was working under extremely unfavorable conditions, which admitted of so great improvements that I am hopeful to magnify the effects many times.

The bony structure of birds, rabbits and the like is shown within the least detail, and even the hollow of the bones is clearly visible. In a plate of a rabbit under exposure of an hour, not only every detail of the skeleton is visible, but likewise a clear outline of the abdominal cavity and the location of the lungs, the fur and many other features. Prints of even large birds show the feathers quite distinctly.

Clear shadows of the bones of human limbs are obtained by exposures ranging from a quarter of an hour to an hour, and some plates have shown such an amount of detail that it is almost impossible to believe that we have to deal with shadows only. For instance, a picture of a foot with a shoe on it was taken, and every fold of the leather, trousers, stocking, etc., is visible, while the flesh and bones stand out sharply. Through the body of the experimenter the shadows of small buttons and like objects are quickly obtained, while with an exposure of from one to one and a half hour the ribs, shoulder-bones and the bones of the upper arm appear clearly, as is shown in the annexed print. It is now demonstrated beyond any doubt that small metallic objects or bony or chalky deposits can be infallibly detected in any part of the body.

An outline of the skull is easily obtained with an exposure of 20 to 40 minutes. In one instance an exposure of 40 minutes gave clearly not only the outline, but the cavity of the eye, the chin and cheek and nasal bones, the lower jaw and connections to the upper one, the vertebral column

TESLA'S RADIOGRAPHS.

We publish a welcome addition to the Roentgen ray literature. It is from the always interesting pen of Nikola Tesla, and is the first authorized description of the experiments of this thorough and conscientious inventor. Mr. Tesla gives full credit to the discovery by Roentgen, and is personally much elated over discoveries of his own as his careful experiments are developed. The Tesla radiographs we present show wonderful results under severe conditions. While Tesla has heretofore been silent since the announcement by Roentgen, he has not been idle, but has evidently been striving for valuable and tangible results. Further information from his laboratory will be awaited with interest.

DECISION ON A VAN DEPOELE RAILWAY PATENT.

An interesting and important decision has just been rendered by Judge Townsend, of the United States Circuit Court for the district of Connecticut, upon the Van Depoele patent No. 495,443, for the under-running electric railway trolley sys-

n interesting and important de-
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onnecticut, upon the Van Depoele
ent No. 495,443, for the under-
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. A few months ago Judge
ynsend rendered a decision sus-
ing the validity of this patent
n final hearing in a suit against
Winchester Avenue Railroad
npany. Shortly thereafter further
ingement suits were brought in
necticut against the Billings &
ncer company, of Hartford, and
Kelsey Electric Railway Specialty
npany, of New Haven. Judge
ynsend has just decided these
s in favor of the Van Depoele
nt, and granted motions for pre-
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t on both sides. The decision is
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t holds that the supply of essen-
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gement, and will be enjoined by
courts, even though the defend-
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rety. The court further held
an unlicensed maker of trolley
s could not be permitted to sup-
uch bases even to railroads which
been originally fully equipped
he General Electric Company,
present owner of Van Depoele
nt No. 495,443.

TESLA ON ROENTGEN RAYS.

(Concluded from page 131.)

are much less efficient for this special object in consequence of the loss through the glass. A popular error seems to exist in regard to the concentration of the rays by concave electrodes. This, if anything, is a disadvantage. There are certain specific arrangements of the disruptive coil and circuits, condensers and static screens for the bulb, on which I have given full particulars on previous occasions.

Having selected the induction apparatus and typé of bulb, the next important consideration is the vacuum. On this subject I am able to make known a fact with which I have long been acquainted, and of which I have taken advantage in the production of vacuum jackets and all sorts of incandescent bulbs, and which I subsequently found to be of the utmost importance, not to say essential, for the production of intense Roentgen shadows. I refer to a method of rarefaction by electrica
means to any degree desirable, fa
beyond that obtainable by mechanica
appliances.

Though this result can be reache
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apparatus, and one which secures the quickest action, is a disruptive coil. It is best to proceed in this way: The bulb is first exhausted by means of an ordinary vacuum pump to a rather high degree, though my experiences have shown that this is not absolutely necessary, as I have also found it possible to rarefy, beginning from low pressure. After being
taken down from the pump, the bulb is attached to the terminal of the disruptive coil, preferably of high frequency of vibration, and usually the following phenomena are noted. First, there is a milky light spreading through the bulb, or possibly for a moment the glass becomes phosphorescent, if the bulb has been exhausted to a high degree. At any rate, the phosphorescence generally subsides quickly and the white light settles around the electrode, whereupon a dark space forms at some distance from the latter. Shortly afterward the light assumes a reddish color and the terminal grows very hot. This heating, however, is observed only with powerful apparatus. It is well to watch the bulb carefully and regulate the potential at this stage, as the electrode might be quickly consumed.

After some time the reddish light subsides, the streams becoming again white, whereupon they get weaker and weaker, wavering around the electrode until they finally disappear. Meanwhile, the phosphorescence of the glass grows more and more intense, and the spot where the stream strikes the wall becomes very hot, while the phosphorescence around the electrode ceases and the latter cools down to such an extent that the glass near it may be actually ice-cold to the touch. The gas in the

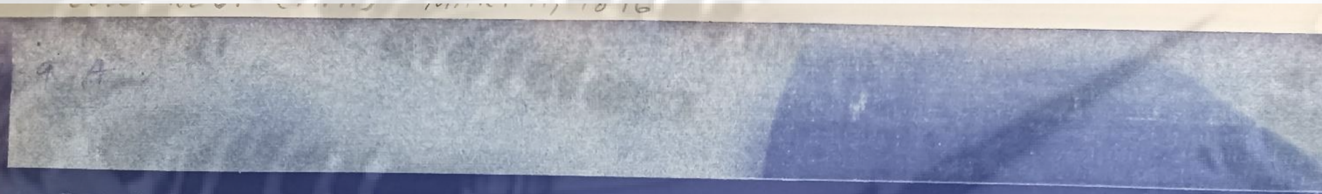

FIG. 1.—PHOTO-ENGRAVING OF TESLA RADIOGRAPH OF RIGHT SHOULDER OF A MAN, SHOWING RIBS AND SHOULDER AND UPPER ARM BONES—TAKEN THROUGH CLOTHING, BOARD, ETC., AT A DISTANCE OF FOUR FEET.

TESLA ON ROENTGEN RAYS.

A HIGHLY INTERESTING AND VALUABLE COMMUNICATION FROM THE TALENTED YOUNG INVENTOR.

TO THE EDITOR OF ELECTRICAL REVIEW:

One can not help looking at that little bulb of Crookes' with a feeling akin to awe, when he considers all that it has done for scientific progress—first, the magnificent results obtained by its originator; next, the brilliant work of Lenard, and finally the wonderful achievements of Roentgen. Possibly it may still contain a grateful Asmodeus, who will be let out of his narrow prison cell by a lucky student. At times it has seemed to me as though I myself heard a whispering voice, and I have searched eagerly among my dusty bulbs and bottles. I fear my imagination has deceived me, but there they are still, my dusty bulbs, and I am still listening hopefully.

After repeating Professor Roentgen's beautiful experiments, I have devoted my energies to the investigation of the nature of the radiations and to the perfecting of the means for their production. The following is a brief statement which, I hope, will be useful, of the methods employed and of the most notable results arrived at in these two directions.

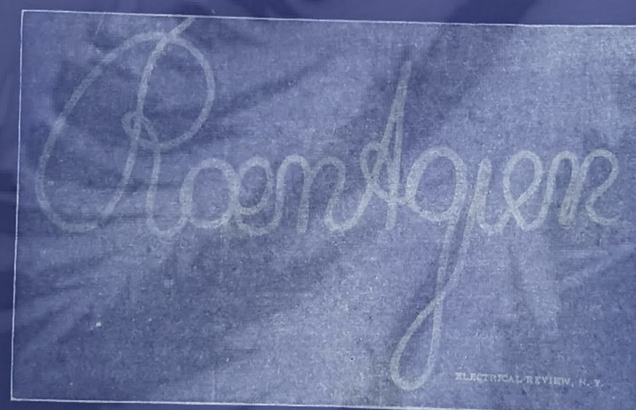

FIG. 2.—TESLA'S RESPECTS TO PROF. ROENTGEN—A RADIOGRAPH OF A WIRE SIGN TAKEN THROUGH A WOODEN COVER AT THE REMARKABLE DISTANCE OF ELEVEN FEET, WITH ONE-HALF HOUR'S EXPOSURE.

In order to produce the most intense effects we have first to consider that, whatever their nature, they depend necessarily on the intensity of the cathode streams. These again being dependent on the magnitude of the potential, it follows that the highest attainable electrical pressure is desirable.

To obtain high potentials we may avail ourselves of an ordinary induction coil, or of a static machine, or of a disruptive discharge coil. I have the impression that most of the results in Europe have been arrived at through the employment of a static machine or Ruhmkorff coil. But since these appliances can produce only a comparatively small potential, we are naturally thrown on the use of the disruptive discharge coil as the most effective apparatus. With this there is practically no limit to the spark length, and the only requirement is that the experimenter should possess a certain knowledge and skill in the adjustments of the circuits, particularly as to resonance, as I have pointed out in my earlier writings on this subject.

After constructing a disruptive coil suitable for any kind of current supply, direct or alternating, the experimenter comes to the consideration as to what kind of bulb to employ. Clearly, if we put two electrodes in a bulb, or use one inside and another outside electrode, we limit the potential, for the presence not only of the anode but of any conducting object has the effect of reducing the practicable potential on the cathode. Thus, to secure the result aimed at, one is driven to the acceptance of a single electrode bulb, the other terminal being as far remote as possible.

Obviously, an inside electrode should be employed to get the highest velocity of the cathode streams, for the bulbs without inside terminals

(Continued on page 184.)

ELEC. REV. (N.Y.) MAR. 11, 1896

TESLA'S STARTLING RESULTS IN RADIOGRAPHY AT GREAT DISTANCES THROUGH CONSIDERABLE THICKNESSES OF SUBSTANCE.

FIG. 1.—PHOTO-ENGRAVING OF TESLA RADIOGRAPH OF R[illegible] SHOULDER OF A MAN, SHOWING RIBS AND SHOULDER AND UPPER ARM BONES—TAKEN THROUGH CLOTHING, BOARDS, ETC., AT A DISTANCE OF FOUR FEET.

Mar. 18, 1896

TESLA'S WORK IN RADIOGRAPHY.

Radiography leads all discoveries of modern times in the intelligent and spontaneous attention it has received from scientists and experimenters all over the civilized world. The announcement of Nikola Tesla's achievements in the new art, first published in the ELECTRICAL REVIEW of March 11, in the author's own modest language, has added fresh impetus to the work in this direction. His disruptive discharge coil has been universally used where the best results in radiography have been obtained, and his two marked improvements, namely, the single electrode tube and his method of rarefaction, promise great results. Other important points about Tesla's work are the fine details he has obtained in his radiographs, the great distance at which the radiographs have been made, and brief time of exposure.

We feel sure that the second communication from Mr. Tesla, which we publish in this issue, will be appreciated by our readers. He now produces shadows at 40 feet distance and promises still more. He, furthermore, brings out the important fact of reflection of the rays, demonstrating this property beyond any doubt, besides other interesting details bearing on the nature of the radiation. To most men the facts presented will appear as a revelation.

The pleasant criticism of our half-tone reproduction of the radiograph of the shoulder of a man is, we admit, justified, but any one who knows the difficulties of the procedure involved will be convinced that as much was done as could be done under the circumstances.

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The pleasant criticism of our half-tone reproduction of the radiograph of the shoulder of a man is, we admit, justified, but any one who knows the difficulties of the procedure involved will be convinced that as much was done as could be done under the circumstances.

Mr. Tesla is pursuing quietly his work and giving all credit to Roentgen; and it is significant, we think, that the first radiograph he produced in his laboratory was the name of the discoverer. We wish that such courtesies among scientists would always be practiced.

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bulbs I frequently experience a sudden, and sometimes even painful, shock in the eye. Such shocks may occur so often that the eye gets inflamed, and one can not be considered over-cautious if he abstains from watching the bulb too closely. I see in these shocks a further evidence of larger particles being thrown off from the bulb. NIKOLA TESLA.

New York, March 14.

DEVELOPMENTS IN RADIOGRAPHY.

WHAT SCIENTISTS AND OTHERS HAVE RECENTLY ACCOMPLISHED.

The New York *Sun* published a dispatch from its London Correspondent, dated March 14, in which it is said that the German Emperor takes the keenest interest in Professor Roentgen's discovery. The statement is made that the Kaiser has had his left arm photographed by the new process. This arm, as every one knows, is quite useless, and the photograph revealed the nature of the malformation. The photograph has been submitted to eminent surgeons, who said that they believe a simple operation may give the Emperor partial, if not complete, use of his left hand and arm.

The first surgical operation in the Johns Hopkins Hospital at Baltimore in which the X-rays were utilized was performed on March 12. It was the extraction of a scissors blade from a woman's hand, where it had been imbedded for 12 years. The position of the steel was revealed by a radiograph.

Prof. W. F. Magie, of Princeton College, spoke, on March 12, before the Princeton Club of New York at its regular March meeting in the Brunswick, on the Roentgen rays and what Princeton was doing toward the development of them. Stereop-

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TESLA'S LATEST RESULTS.

HE NOW PRODUCES RADIOGRAPHS AT A DISTANCE OF MORE THAN FORTY FEET.

To the Editor of Electrical Review:

Permit me to say that I was slightly disappointed to note in your issue of March 11 the prominence you have deemed to accord to my youth and talent, while the ribs and other particulars of Fig. 1, which, with reference to the print accompanying my communication, I described as clearly visible, were kept modestly in the background. I also regretted to observe an error in one of the captions, the more so, as I must ascribe it to my own text. I namely stated on page 135, third column, seventh line: "A similar impression was obtained through the body of the experimenter, etc., through a distance of four feet." The impression here referred to was a similar one to that shown in Fig. 2, whereas the shadow in Fig. 1 was taken through a distance of 18 inches. I state this merely for the sake of correctness of my communication, but, as far as the general truth of the fact of taking such a shadow at the distance given is concerned, your caption might as well stand, for I am producing strong shadows at distances of *40 feet*. I repeat, 40 feet and even more. Nor is this all. So strong are the actions on the film that provision must be made to guard the plates in my photographic department, located on the floor above, a distance of fully 60 feet, from being spoiled by long exposure to the stray rays. Though during my investigations I have performed many experiments which seemed extraordinary, I am deeply astonished observing these unexpected manifestations, and still more so, as even now I see before me the possibility, not to say certitude, of augmenting the effects with my apparatus at least tenfold! What may we then expect? We have to deal here, evidently, with a radiation of astonish-

on the film that provision must be made to guard the plates in my photographic department, located on the floor above, a distance of fully 60 feet, from being spoiled by long exposure to the stray rays. Though during my investigations I have performed many experiments which seemed extraordinary, I am deeply astonished observing these unexpected manifestations, and still more so, as even now I see before me the possibility, not to say certitude, of augmenting the effects with my apparatus at least tenfold! What may we then expect? We have to deal here, evidently, with a radiation of astonish-
ing power, and the inquiry into its nature becomes more and more interesting and important. Here is an unlooked-for result of an action which, though wonderful in itself, seemed feeble and entirely incapable of such expansion, and affords a good example of the fruitfulness of original discovery. These effects upon the sensitive plate at so great a distance I attribute to the employment of a bulb with a single terminal, which permits the use of practically any desired potential and the attainment of extraordinary speeds of the projected particles. With such a bulb it is also evident that the action upon a fluorescent screen is proportionately greater than when the usual kind of tube is employed, and I have already observed enough to feel sure that great developments are to be looked for in this direction. I consider Roentgen's discovery, of enabling us to see, by the use of a fluorescent screen, through an opaque substance, even a more beautiful one than the recording upon the plate.

Since my previous communication to you I have made considerable progress, and can presently announce one more result of importance. I have lately obtained shadows by *reflected rays only*, thus demonstrating beyond doubt that the Roentgen rays possess this property. One of the experiments may be cited here. A thick copper tube, about a foot long, was taken and one of its ends tightly closed by the plate-holder containing a sensitive plate, protected by a fiber cover as usual. Near the open end of the copper tube was placed a thick plate of glass at an angle of 45 degrees to the axis of the tube. A single-terminal bulb was then suspended above the glass plate at a distance of about eight inches, so that the bundle of rays fell upon the latter at an angle of 45 degrees, and the supposedly reflected rays passed along the axis of the copper tube. An exposure of 45 minutes gave a clear and sharp shadow of a metallic object. This shadow was produced by the reflected rays, as the direct action was absolutely excluded, it having been demonstrated that even under the severest tests with much stronger actions no impression whatever could be produced upon the film through a thickness of copper equal to that of the tube. Concluding from the intensity of the action by comparison with an equivalent effect due to the direct rays, I find that approximately two per cent of the latter were reflected from the glass plate in this experiment. I hope to be able to report shortly and more fully on this and other subjects.

In my attempts to contribute my humble share to the knowledge of the Roentgen phenomena, I am finding more and more evidence in support of the theory of moving material particles. It is not my intention, however, to advance at present any view as to the bearing of such a fact upon the present theory of light, but I merely seek to establish the fact of the existence of such material streams in so far as these isolated effects are concerned. I have already a great many indications of a bombardment occurring outside of the bulb, and I am arranging some crucial tests which, I hope, will be successful. The calculated velocities fully account for actions at distances of as much as 100 feet from the bulb, and that the projection through the glass takes place seems evident from the process of exhaustion, which I have described in my previous communication. An experiment which is illustrative in this respect, and which I intended to mention, is the following: If we attach a fairly exhausted bulb containing an electrode

concerned. I have already a great many indications of a bombardment occurring outside of the bulb, and I am arranging some crucial tests which, I hope, will be successful. The calculated velocities fully account for actions at distances of as much as 100 feet from the bulb, and that the projection through the glass takes place seems evident from the process of exhaustion, which I have described in my previous communication. An experiment which is illustrative in this respect, and which I intended to mention, is the following: If we attach a fairly exhausted bulb containing an electrode
to the terminal of a disruptive coil, we observe small streamers breaking through the sides of the glass. Usually such a streamer will break through the seal and crack the bulb, whereupon the vacuum is impaired; but, if the seal is placed above the terminal, or if some other provision is made to prevent the streamer from passing through the glass at that point, it often occurs that the stream breaks out through the side of the bulb, producing a fine hole. Now, the extraordinary thing is that, in spite of the connection to the outer atmosphere, the air can not rush into the bulb as long as the hole is very small. The glass at the place where the rupture has occurred may grow very hot—to such a degree as to soften; but it will not collapse, but rather bulge out, showing that a pressure from the inside greater than that of the atmosphere exists. On frequent occasions I have observed that the glass bulges out and the hole, through which the streamer rushes out, becomes so large as to be perfectly discernible to the eye. As the matter is expelled from the bulb the rarefaction increases and the streamer becomes less and less intense, whereupon the glass closes again, hermetically sealing the opening. The process of rarefaction, nevertheless, continues, streamers being still visible on the heated place until the highest degree of exhaustion is reached, whereupon they may disappear. Here, then, we have a positive evidence that matter is being expelled through the walls of the glass.

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TESLA'S LATEST CONTRIBUTION TO SCIENCE.

We publish in this issue a communication from Mr. Tesla, which is even more interesting and important than his previous contributions presented in our columns. After announcing the extraordinary results obtained by means of his apparatus, which speak for the correctness of his conclusions regarding the character of the radiations, and after proving in crucial tests the long-sought-for property of reflection, he makes known a result which will probably lead to one of the most important realizations in science. His investigations of the reflective power of conductors disclose a singular relationship which seems capable of leading us to a deeper insight into the primary condition of matter than we have ever been able to obtain heretofore. Why is zinc, for instance, which is one of the first in Volta's electric contact series, one of the best reflectors? asks Tesla. Evidently such can only be the case if these mysterious rays emanating from the bulb convey matter in its primary state or condition. Let us hope that soon the full light of day will illuminate these obscure but immensely promising fields.

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TESLA ON REFLECTED ROENTGEN

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TESLA ON REFLECTED ROENTGEN RAYS.

(Concluded from page 171.)

This is easily done by reducing the number of impulses or their duration, when raising the potential. For such experiments, it will be found of advantage to use in connection with the ordinary induction coil a rotating commutator, instead of a vibrating brake. By changing the speed of the commutator, and also regulating the duration of contact, one is enabled to adjust the conditions to suit the degree of vacuum and potential employed.

In my experiments on reflection, presently considered, I have used the apparatus shown in Fig. 2. It consists of a T-shaped box throughout, of a square cross-section. The walls are made of lead over one-eighth of an inch thick, which, under the conditions of the experiments, was found to be entirely impervious, even by long exposures to the rays. On the top end was supported firmly the bulb b, inclosed in a glass tube t of thick Bohemian glass, which reached some distance into the lead box. The lower end of the box was tightly closed by a plate-holder P_1, containing the sensitive film p_1, protected as usual. Finally the side end was closed by a similar plate-holder P, with the sensitive protected film p. To obtain sharp images the objects o and o_1, exactly alike, were placed in the center of the fiber cover, protecting the sensitive plates. In the central portion of the box, provision was made for inserting a plate r of material, the reflective power of which was to be tested, and the dimensions of the box were such that the reflected ray and the direct one had to go through the same distance, the reflecting plate being at an angle of 45 degrees to the incident as well as reflected ray. Care was taken to exclude all possibility of action upon the plate p, except by reflected rays, and the reflecting plate r was made to fit tight all around in the lead box, so that no rays could reach the film p_1, except by passing through the plate to be tested. In my earliest experiments on reflection I observed only the effects of reflected rays, but in this instance, on the suggestion of Prof. Wm. A. Anthony, I provided the above means for simultaneously examining the action of the direct rays, which eventually passed through the reflecting plate. In this manner it was possible to compare the amount of the trans-

mary of the observations is given in the following table:

Reflecting body.	Impression by transmitted rays.	Impression by reflected rays.
Brass.	Strong.	Fairly strong.
Toolsteel.	Barely perceptible.	Very feeble.
Zinc.	None.	Very strong.
Aluminum.	Very strong.	None.
Copper.	None.	Fairly strong, but much less than zinc.
Lead.	None.	Very strong, but a little weaker than zinc.
Silver.	Strong, a thin plate being used.	Weaker than copper.
Tin.	None.	Very strong; about like lead.
Nickel.	None.	About like copper.
Lead-glass.	Very strong.	Feeble.
Mica.	Very strong.	Very strong; about like lead.
Ebonite.	Strong.	About like copper.

By comparing, as in previous experiments, the intensity of the impression by reflected rays with an equivalent impression due to a direct exposure of the same bulb and at the same distance—that is, by calculating from the times of exposure under assumption that the action upon the plate was proportionate to the time—the following approximate results were obtained:

Reflecting body.	Impression by direct action.	Impression by reflected rays.
Brass	100	2
Toolsteel	100	0.5
Zinc	100	3
Aluminum	100	0
Copper	100	2
Lead	100	2.5
Silver	100	1.75
Tin	100	2.5
Nickel	100	2
Lead-glass	100	1
Mica	100	2.5
Ebonite	100	2

While these figures can be but rough approximations, there is, nevertheless, a fair probability that they are correct, in so far as the relative values of the impressions by reflected rays for the various bodies are concerned. Arranging the metals according to these values, and leaving for the moment the alloys or impure bodies out of question, we arrive at the following order: Zinc, lead, tin, copper, silver. The tin appears to

gated the subject and find that I can not agree with this contention. On the contrary, I find that anodic and cathodic streams both affect the plate, and, furthermore, I have been led to the conviction that the phosphorescence of the glass has nothing whatever to do with the photographic impressions. An obvious proof is that such impressions are produced with aluminum vessels when there is no phosphorescence, and, as regards the anodic or cathodic character, the simple fact that we can produce impressions by a luminous discharge excited by induction of a closed vessel, when there is neither anode nor cathode, would seem to dispose effectually of the assumption that the streams are issuing solely from one of the electrodes. It may, perhaps, be useful to point out here a simple fact in relation to the induction coils, which may lead an experimenter into an error. When a vacuum tube is attached to the terminals of an induction coil, both of the terminals are acted upon alike as long as the tube is not very highly exhausted. At a high degree of exhaustion both the electrodes act practically independently, and since they behave as bodies possessing considerable capacity, the consequence is that the coil is unbalanced. If the cathode, for instance, is very large, the pressure on the anode may rise considerably, and if the latter is made smaller, as is frequently the case, the electric density may be many times that on the cathode. It results from this that the anode gets very hot, while the cathode may be cool. Quite the opposite occurs if both of them are made exactly alike. But assuming the above conditions to exist, the hotter anode emits a more intense stream than the cool cathode, since the velocity of the particles is dependent on the electrical density, and likewise on the temperature.

THE LUNDELL "WHITE WINGS" ELECTRIC FAN.

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To reduce the error which is caused unavoidably by too long exposures and very small distances, I reduced the exposure to an hour, and the total distance through which the rays had to pass before reaching the sensitive plates was 20 inches, the distance from the bottom of the bulb to the reflecting plate being 13 inches.

It is needless to remark that all the precautions in regard to the sensitive plates—constancy of potential, uniform working of the bulbs, and maintenance of the same conditions in general during these tests have been taken, as far as it was practicable. The plates to be tested were made of uniform size, so as to fit the space provided in the lead box. Of the conductors the following were tested: Brass, toolsteel, zinc, aluminum, copper, lead, silver, tin, and nickel, and of the insulators, lead-glass, ebonite, and mica. The sum-

Body.		
Brass	100	[illegible]
Toolsteel	100	0.5
Zinc	100	3
Aluminum	100	0
Copper	100	2
Lead	100	2.5
Silver	100	1.75
Tin	100	2.5
Nickel	100	2
Lead-glass	100	1
Mica	100	2.5
Ebonite	100	2

While these figures can be but rough approximations, there is, nevertheless, a fair probability that they are correct, in so far as the relative values of the impressions by reflected rays for the various bodies are concerned. Arranging the metals according to these values, and leaving for the moment the alloys or impure bodies out of question, we arrive at the following order: Zinc, lead, tin, copper, silver. The tin appears to reflect fully as well as lead, but, allowing for an error in the observation, we may assume that it reflects less, and in this case we find that this order is precisely the contact series of metals in air. If this proves true we shall be confronted with the most extraordinary fact. Why is zinc, for instance, the best reflector among the metals tested and why, at the same time, is it one of the foremost in the contact series? I have not as yet tried magnesium. The truth is that I was somewhat excited over these results. Magnesium should be even a better reflector than zinc, and sodium still better than magnesium. How can this singular relationship be explained? The only possible explanation seems to me at present that the bulb throws out streams of matter in some primary condition, and that the reflection of these streams is dependent upon some fundamental and electrical property of the metals. This would seem to lead to the inference that these streams must be of uniform electrification; that is, that they must be anodic or cathodic in character, but not both. Since the announcement, I believe in France for the first time, that the streams are anodic, I have investi-

THE LUNDELL "WHITE WINGS" ELECTRIC FAN.

pendently, and since they behave as bodies possessing considerable capacity, the consequence is that the coil is unbalanced. If the cathode, for instance, is very large, the pressure on the anode may rise considerably, and if the latter is made smaller, as is frequently the case, the electric density may be many times that on the cathode. It results from this that the anode gets very hot, while the cathode may be cool. Quite the opposite occurs if both of them are made exactly alike. But assuming the above conditions to exist, the hotter anode emits a more intense stream than the cool cathode, since the velocity of the particles is dependent on the electrical density, and likewise on the temperature.

From the previous tests an interesting observation can also be made in regard to the opacity. For instance, a brass plate one-sixteenth inch thick proved fairly transparent, while plates of zinc and copper of the same thickness showed themselves to be entirely opaque.

Since I have investigated reflection and arrived to results in this direction, I have been able to produce stronger effects by employing proper reflectors. By surrounding a bulb with a very thick glass tube the effect may be augmented very considerably. The employment of a zinc reflector in one instance showed an increase of about 40 per cent in the impression produced. I attach great practical value to the employment of proper reflectors, because by means of them we can employ any quantity of bulbs, and so produce any intensity of radiation required.

One disappointment in the course of these investigations has been the entire failure of my efforts to demonstrate refraction. I have employed lenses of all kinds and tried a great many experiments, but could not obtain any positive result.

NIKOLA TESLA.

New York, March 30.

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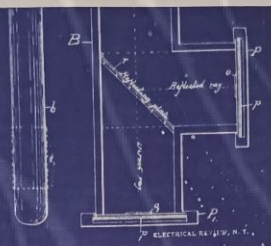
equal a century of progress. A delight it would be to live in such age, but a discoverer I would not wish to be.

Amongst the facts, which I have had the honor to bring to notice, is one claiming a large share of scientific interest, as well as of practical importance. I refer to the demonstration of the property of reflection, on which I have dwelt briefly.

Having had opportunities to make many observations during my experience with vacuum bulbs and tubes, which could not be accounted for in any plausible way on any theory of vibration as far as I could judge, I began these investigations—disinclined, but expectant to find that the effects produced are due to a stream of material particles. I had many evidences of the existence of such streams. One of these I mentioned, describing the method of electrically exhausting a tube. Such exhaustion, I have found, takes place much quicker when the glass is very thin than when the walls are thick, I presume because of the easier passage of the ions. While a few minutes are sufficient when the glass is very thin, it often takes half an hour or more if the glass be thick or the electrode very large. In accordance with this idea I have, with a view of obtaining the most efficient action, selected the apparatus, and have found at each step my supposition confirmed and my conviction strengthened.

A stream of material particles, possessing a great velocity, must needs be reflected, and I was therefore quite prepared—assuming my original idea to be true—to demonstrate sooner or later this property. Considering that the reflection should be the more complete the smaller the angle of incidence, I adopted from the outset of my investigations a tube or bulb b of the form shown in Fig. 1. It was made of very thick glass, with a bot-



FIGS. 1 AND 2.—ILLUSTRATING TESLA'S EXPERIMENTS ON REFLECTED ROENTGEN RAYS.

the radiation sideways was restricted by the use of a very thick glass and most of it was thrown to the bottom by reflection, as I then surmised, it became evident that such a tube should prove much more efficient than one of ordinary form. Indeed, I quickly found that its power upon the sensitive plate was very nearly four times as great as that of a spherical bulb with an equivalent area of impact. This kind of tube is also very well adapted for use with two terminals by placing an external electrode e_1 as indicated by the dotted lines in Fig. 1. When the glass is taken thick the stream is sensibly parallel and concentrated. Furthermore, by making the tube as long as one desired, it was possible to employ very high potentials, otherwise impracticable with short bulbs.

The use of high potentials is of great importance, as it allows shortening considerably the time of exposure, and affecting the plate at much greater distances. I am endeavoring to determine more exactly the relation of the potential to the effect produced upon the sensitive plate. I deem it necessary to remark that the electrode should be of aluminum, that when the Crookes phenomena show themselves most prominently there is a reddish streamer issuing from the electrode, which in the beginning covers the latter almost entirely. Up to this point the bulb practically does not affect the sensitive plate, although the glass is very hot at the point of impact. Gradually the reddish streamer disappears, and just before it ceases to be visible the bulb begins to show better action, but still the effect upon the plate is very weak. Presently a white or even bluish stream is observed, and after some time the glass on the bottom of the bulb gets a glossy appearance. The heat is still more intense and the phosphorescence through the entire bulb is extremely brilliant. One should think that such a bulb must be effective, but appearances are often deceitful, and the beautiful bulb still does not work. Even when the white or bluish stream ceases, and the glass on the bottom is so hot as to be nearly melting, the effect on the plate is very weak. But at this stage there appears suddenly at the bottom of the tube a star-shaped changing design, as if the electrode would throw off drops of liquid. From this moment on the power of the bulb is tenfold, and at this stage it must always be kept to give the best results.

I may remark, however, that while it may be generally stated the Crookes vacuum is not high enough for the production of the Roentgen phenomena, this is not literally true. Nor are the Crookes phenomena produced at a particular degree of exhaustion, but manifest themselves even with poor vacua, provided the potential is high enough. This is likewise true of the Roentgen effects. Naturally, to verify this, provision must be made not to overheat the bulb when the potential is raised.

(Concluded on page 174.)

APR. 1, 1896

TESLA ON REFLECTED ROENTGEN RAYS.

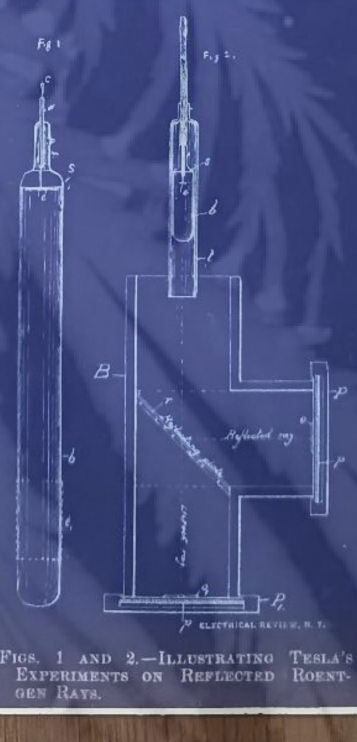
To the Editor of Electrical Review:

In previous communications to your esteemed journal in regard to the effects discovered by Roentgen, I have confined myself to giving barely a brief outline of the most noteworthy results arrived at in the course of my investigations. To state truthfully, I have ventured to express myself, the first time, after some hesitation and consequent delay, and only when I had gained the conviction that the information I had to convey was a needful one; for, in common with others, I was not quite able to free myself of a certain feeling which one must experience when he is trespassing on ground not belonging to him. The discoverer would naturally himself arrive at most of the facts in due time, and a courteous restraint in the announcement of the results on the part of his co-workers would not be amiss. How many have sinned against me by proclaiming their achievements just as I was good and ready to do it myself! But these discoveries of Roentgen, exactly of the order of the telescope and microscope, his seeing through a great thickness of an opaque substance, his recording on a sensitive plate of objects otherwise invisible, were so beautiful and fascinating, so full of promise, that all restraint was put aside, and every one abandoned himself to the pleasures of speculation and experiment. Would but every new and worthy idea find such an echo! One single year would then equal a century of progress. A delight it would be to live in such age, but a discoverer I would not wish to be.

Amongst the facts, which I have had the honor to bring to notice, is one claiming a large share of scientific interest, as well as of practical importance. I refer to the demonstration of the property of reflection, on which I have dwelt briefly.

Having had opportunities to make many observations during my experience with vacuum bulbs and tubes, which could not be accounted for in any plausible way on any theory of vibration as far as I could judge, I began these investigations—disin-

tom blown as thin as possible, with the two obvious objects of restricting the radiation to the sides and facilitating the passage through the bottom. A single electrode *e*, in the form of a round disk of a diameter slightly less than that of the tube, was placed about an inch below the narrow neck *n* on the top. The leading-in conductor *c* was provided with a long wrapping *w*, so as to prevent cracking, by the formation of sparks at the point where the wire enters the bulb. It was found advantageous for a number of reasons to extend the wrapping a good distance beyond the neck, on the inside and outside as well, and to place the seal-off in the narrow neck. On other occasions I have dwelt on the employment of an electrostatic screen in connection with such single-terminal bulbs. In the present instance the screen was preferably formed by a bronze painting *s*, slightly above the aluminum electrode and extending to just a little below the wrapping of the wire, so as to allow seeing constantly the end of the wrapping. Or else a small aluminum plate *s*, Fig. 2, was supported in the inside of the bulb above the electrode. This static screen practically doubles the effect, as it prevented all action above it. Considering, further, that



Figs. 1 and 2.—Illustrating Tesla's Experiments on Reflected Roentgen Rays.

as a platinum electrode, which is still persistently employed, gives inferior results, and the bulb is disabled in comparatively short time. Some experimenters might find trouble in maintaining a fairly constant vacuum, owing to a peculiar process of absorption in the bulb, which has been pointed out early by Crookes, in consequence of which, by continued use, the vacuum may increase. A convenient way to prevent this I have found to be the following: The screen or aluminum plate *s*, Fig. 2, is placed directly upon the wrapping of the leading-in conductor *c*, but some distance back from the end. The right distance can be only determined by experience. If it is properly chosen, then, during the action of the bulb, the wrapping gets warmer, and a small bright spark jumps from time to time from the wire *c* to the aluminum plate *s* through the wrapping *w*. The passage of this spark causes gases to be formed, which slightly impair the vacuum, and in this manner, by a little skillful manipulation, the proper vacuum may be constantly maintained. Another way of getting the same result in a tube shown in Fig. 1 is to extend the wrapping so far inside that, when the bulb is normally working, the wrapping is heated sufficiently to free gases to the required amount. It is for this purpose convenient to let the screen of bronze painting *s* extend just a little below the wrapping, so that the spark may be observed. There are, however, many other ways of overcoming this difficulty, which may cause some annoyance to those working with inadequate apparatus.

In order to insure the best action the experimenter should note the various stages which I have pointed out before, and through which the bulb has to pass during the process of exhaustion. He will first observe that when the Crookes phenomena show themselves most prominently there is a reddish streamer issuing from the electrode, which in the beginning covers the latter almost entirely. Up to this point the bulb practically does not affect the sensitive plate, although the glass is very hot at the point of impact. Gradually the reddish streamer disappears, and just before it ceases to be visible the bulb begins to show better action, but still the effect upon the plate is very weak. Presently a white or even bluish stream is observed, and after some time the glass on the bottom of the bulb gets a glossy appearance.

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formance of this screen was particularly noteworthy. It was illuminated at a distance of 20 feet, and even at a distance of 40 feet I could still observe a faint shadow passing across the field of vision, when moving the hand in front of the instrument. Looking at a distance of about three feet from the bulb through the body of an assistant, I could distinguish easily the spinal column in the upper part of the body, which was more transparent. In the lower part of the body the column and the rest were practically not perceptible. The ribs were only very faintly seen. The bones of the neck were plainly noticeable, and I could see through the

must be admitted that the performance of such a screen is remarkable with the appliances I have used, I have, nevertheless, convinced myself of its still limited value for the purpose of examination. We can distinguish the bones in the limbs, but not nearly as clearly as a photographic impression shows it. Eventually, however, with the help of strong radiations and good reflectors, such fluorescent screens may become valuable instruments for investigation. A few weeks ago, when I observed a small screen of barium-platino-cyanide flare up at a great distance from the bulb, I told some friends that it might be possible to observe by the aid of such a screen objects passing through a street. This possibility seems to me much nearer at present than it appeared then. Forty feet is a fair width for a street, and a screen lights up faintly at that distance from a single bulb. I mention this odd idea only as an illustration of how these scientific developments may even affect our morals and customs. Perhaps we shall shortly get so used to this state of things that nobody will feel the slightest embarrassment while he is conscious that his skeleton and other particulars are being scrutinized by indelicate observers.

Fluorescent screens afford some help in getting an idea of the condition of the bulb when working. I hoped to find some evidence of refraction by means of such a screen, placing a lens between it and the bulb, and varying the focal distance. To my disappointment, although the shadow of the lens was observable at a distance of 20 feet, I could see no trace of refraction. The use of the screen for the purpose of noting the effects of reflection and diffraction proved likewise futile.

NIKOLA TESLA.

New York, April 6.

PERSONAL.

Mr. A. K. Baylor, of the General Electric Company's railway department, sailed for Europe on Tuesday

ELEC. REV. (N.Y.) APR. 8, 1896

TESLA ON ROENTGEN RADIATIONS.

To the Editor of Electrical Review:

Having observed the unexpected behavior of the various metals in regard to the reflection of these radiations, as communicated in your issue of April 1, I have endeavored to settle several still doubtful points. As, for the present, it appeared chiefly desirable to establish the exact order of the metals, or conductors, in regard to their powers of reflection, leaving for further investigation the determination of the magnitude of the effects, I modified slightly the apparatus and procedure described in my communication just referred to. The reflecting plates were not made each of one metal, as before, but of two metals, the reflective power of which was to be compared. This was done by fastening upon a plate of lead the two metal plates to be investigated, so that the reflecting surface was divided in two halves by the joining line. Furthermore, to prevent any spreading and mingling of the rays reflected from both halves, I divided the lead box into two compartments by a thick lead plate through the middle. Care was taken that the density of the rays falling upon the reflecting surfaces was as uniform as possible, and with this object in view the glass tube surrounding the bulb was lifted up so as to just expose the half-spherical bottom of the latter. The bulb was placed as exactly as it was practicable in the center, so that both halves of the reflecting plate were equally exposed to the radiations.

Having failed to obtain, in former experiments, a record for iron owing to an oversight, I tried to ascertain its position in the series by comparing it with copper, using a plate made up of iron and copper. The experiments showed that iron reflected about as much as copper, but which metal reflected better was im-

the glass tube surrounding the bulb was lifted up so as to just expose the half-spherical bottom of the latter. The bulb was placed as exactly as it was practicable in the center, so that both halves of the reflecting plate were equally exposed to the radiations.

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possible to determine with safety by this method. Next I endeavored to find whether tin or lead was a better reflector, by the same method. Three experiments were performed, and in each case the metals behaved nearly alike, but tin appeared just a trifle better. Finally I investigated the properties of magnesium as compared with zinc. In fact, the experiments showed that magnesium reflected a little better.

I am not yet satisfied, in view of the importance of this relation of the metals with the means employed, and will try to devise an apparatus which will do away with all the defects of the present. The time of the exposure I have found practicable to reduce to a few minutes by the help of a fluorescent paper.

In my previous communications I have barely hinted at the practical importance of the use of suitable reflectors. One would be apt to conclude that, since, under the conditions of the previously described experiments, zinc, for instance, reflected only three per cent of the incident rays, the gain secured by the employment of such zinc reflector would be small. This, of course, would be an erroneous conclusion. First of all it should be remembered that in the instances mentioned before the angle of incidence was 45 degrees, and that for larger angles a much greater portion of the rays would be reflected. The exact law of reflection is still to be determined. Now, let us suppose the shadow of an object is taken at a distance, D. In order to get a sharp shadow we must take this distance not less than two feet, and I am finding it more and more necessary to adopt a still greater distance. If, for the sake of simplicity, we assume a spherical bulb and electrode, the radiation will be uniform on all sides, and any element of a surface of a sphere of radius D, drawn around the electrode, will receive an equal quantity of rays. The total surface of this sphere will be $4\pi D^2$. The object, the shadow of which is to be taken, may have a small area a, which gets only an insignificant part of the total rays emitted, this part being given by the proportion $\frac{a}{4\pi D^2}$. In reality we can not assume less than $\frac{a}{D^2\pi}$ as effective ratio, but even then, if D is very large and the object, that is, the area a, small, this ratio may be still so small that evidently, by the use of a proper reflector, we can easily concentrate upon the area a an amount of rays several times exceeding that which would fall upon it without the use of a reflector, in spite of the fact that we are able to reflect only a few per cent of the *total* incident rays.

As an evidence of the effectiveness of such a reflector, the annexed print of the shoulder and ribs of a man is shown. A funnel-shaped zinc reflector, two feet high, with an opening of five inches on the bottom and 23 inches at the top, was used in the experiment. A tube, similar in every respect to those previously described, was suspended in the funnel, so that just the static screen of the tube was above the former. The exact distance from the electrode to the sensitive plate was four and one-half feet. The distance from the end of the tube to the plate was three and one-half feet. The exposure lasted 40 minutes. The plate showed very strongly and clearly every bone, and shoulder and ribs, but I can not tell how clearly they will appear in the print. I selected the same object as in my first report in your columns on this investigation, so as to give a better idea of the progress made. The advance will be best appreciated

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by stating that the distance in this case was much more than double, while the time of exposure was less than one-half. The chief importance of a reflector consists, however, in this, that it allows the use of many bulbs without sacrifice of precision and clearness, and also the concentration of a great quantity of radiation upon a very small area.

Since the use of phosphorescent or fluorescent bodies in connection with the sensitive film has been suggested by Professors Henry and Salvioni, I have found it an easy matter to shorten the time of exposure to a few minutes, or even seconds. So far, it seems that the tungstate of calcium, recently introduced by Edison, and manufactured by Messrs. Aylsworth & Jackson, is the most sensitive body. I obtained a sample of it and used it in a series of tests. It fluoresces decidedly better than barium-platinocyanide, but, owing to the size of the crystals and necessarily uneven distribution on the paper, it does not leave a clean impression. For use in connection with the sensitive films, it should be ground very fine, and some way should be adopted of distributing it uniformly. The paper also must adhere firmly to the film all over the plate, so as to get fairly sharp outlines. The fluorescence of this body seems to depend on a peculiar radiation, because I tested several bulbs, which otherwise worked excellently, without producing a very good result, and I almost gained a false impression. One or two of the bulbs, how-

(Concluded on page 186.)

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before described, taking an impression of the chest of an assistant at a distance of four feet from the bulb.

it is evident that, when using the above means for shortening the time of exposure, the thickness of the

ribs were only very faintly seen. The bones of the neck were plainly noticeable, and I could see through the

TESLA'S RADIOGRAPH OF A MAN'S SHOULDER AND RIBS THROUGH CLOTHING BY MEANS OF A REFLECTOR.—EXPOSURE FORTY MINUTES, DISTANCE FOUR FEET—IMPRESSION PRODUCED WITHOUT A PHOSPHORESCENT INTENSIFIER. (SHIRT BUTTON ON TOP OF SHOULDER PLAINLY SHOWN.)

The latter was strained a little too much in this experiment and exploded, in consequence of the great internal pressure against the bombarded spots. This accident will fre-

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body of the assistant very easily a square plate of copper, as it was moved up and down in front of the bulb. When looking through the head I could observe only the outline

TESLA ON ROENTGEN RADIATIONS.

(Concluded from page 183.)

ever, effected it very powerfully. An impression of the hand was taken at a distance of about six feet from the bulb with an exposure of less than one minute, and even then it was found that the plate was overexposed. I then took an impression of the chest of a man at a distance of 12 feet from the end of the tube, exposing five minutes. The developed plate showed the ribs clearly, but the outlines were not sharp. Next, I employed a tube with a zinc reflector, as before described, taking an impression of the chest of an assistant at a distance of four feet from the bulb. for these ominous signs and instantly reduce the potential. Owing to the untimely end of the bulb in this last described experiment, the exposure lasted only one minute. Nevertheless, a very strong impression of the skeleton of the chest, showing the right and left ribs and other details, was obtained. The outlines, however, were again much less sharp than when the ordinary process without the phosphorescent intensifier was followed, although care was taken to press the fluorescent paper firmly against the film. From the foregoing it is evident that, when using the above means for shortening the time of exposure, the thickness of the formance of this screen was particularly noteworthy. It was illuminated at a distance of 20 feet, and even at a distance of 40 feet I could still observe a faint shadow passing across the field of vision, when moving the hand in front of the instrument. Looking at a distance of about three feet from the bulb through the body of an assistant, I could distinguish easily the spinal column in the upper part of the body, which was more transparent. In the lower part of the body the column and the rest were practically not perceptible. The ribs were only very faintly seen. The bones of the neck were plainly noticeable, and I could see through the

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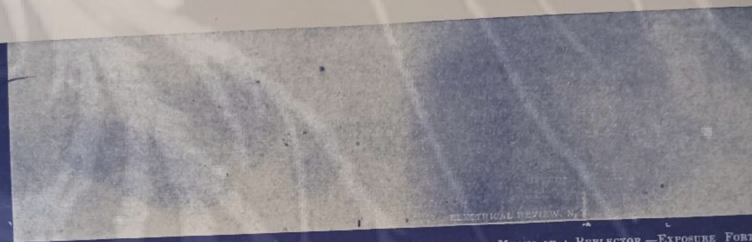

TESLA'S RADIOGRAPH OF A MAN'S SHOULDER AND RIBS THROUGH CLOTHING BY MEANS OF A REFLECTOR.—EXPOSURE FORTY MINUTES, DISTANCE FOUR FEET.—IMPRESSION PRODUCED WITHOUT A PHOSPHORESCENT INTENSIFIER. (SHIRT BUTTON ON TOP OF SHOULDER PLAINLY SHOWN.)

The latter was strained a little too much in this experiment and exploded, in consequence of the great internal pressure against the bombarded spot. This accident will frequently occur when the bulb is strained too high, the preceding outward sign being an increased activity and vapor-like appearance of the gas in the bulb and rapid heating of the latter. The process causing the abnormal increase in the internal pressure against the glass wall seems to be due to some action opposite to that noted by Crookes and Spottiswoode, and is very rapid, and for this reason the experimenter should watch carefully object is not of very much consequence.

I obtained a still better idea of the quality of tungstate of calcium by observing the effect upon a fluorescent screen made of this chemical. Such a screen, together with a paper box, has been termed with the fanciful name "fluoroscope." It is really Salvioni's Cryptoscope with the lens omitted, which is a great disadvantage. To appreciate the performances of such a screen, it is necessary to work at night, when the eye has for a long time been used to the darkness, and made capable of noting the faint effects on the screen. In one instance the per- body of the assistant very easily a square plate of copper, as it was moved up and down in front of the bulb. When looking through the head I could observe only the outline of the skull and the chin-bone, yet the field of vision was still bright. Everything else appeared indistinct. This shows that improving of fluorescence will not aid us very much in the examination of the internal parts of the body. The solution rather will come through the production of very powerful radiations, capable of producing very strong shadows. I believe I have indicated the right way to secure this result. Although it

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saving in its manufacturing cost besides securing other and equally important advantages.

Tesla's latest investigations of the many interesting scientific questions arising from the Roentgen ray discovery are published in this issue. No step in the various stages that he has so far presented to the readers of the ELECTRICAL REVIEW is more interesting or suggestive. The relation which he demonstrates to exist between the series obtained by arranging the metals according to their reflective power and Volta's contact series in air, proves that the rays emitted from the bulb are not an isolated phenomenon, but are emitted everywhere. Particularly suggestive is the observation that all conductors emit streams similar to those discovered by Roentgen, and that the sun and other sources of radiant energies must pour forth rays of the nature of the cathode. To those devoted chiefly to the practical applications of Roentgen's discovery, Tesla's latest observations with a fluorescent screen, showing that even the heart can be seen, will appear most promising, while his investigation of the important effect discovered by Prof. J. J. Thomson (who has contributed so much to the advancement along these lines) can not fail to be of the greatest interest to scientific men.

THE PATENT COMMITTEE COMPLETED.

TESLA'S LATEST ROENTGEN RAY INVESTIGATIONS.

TO THE EDITOR OF ELECTRICAL REVIEW:

Further investigations concerning the behavior of the various metals in regard to reflection of these radiations have given additional support to the opinion which I have before expressed; namely, that Volta's electric contact series in air is identical with that which is obtained when arranging the metals according to their powers of reflection, the most electro-positive metal being the best reflector. Confining myself to the metals easily experimented upon, this series is magnesium, lead, tin, iron, copper, silver, gold and platinum. The last-named metal should be found to be the poorest, and sodium one of the best, reflectors. This relation is rendered still more interesting and suggestive when we consider that this series is approximately the same which is obtained when arranging the metals according to their energies of combination with oxygen, as calculated from their chemical equivalents.

Should the above relation be confirmed by other physicists, we shall be justified to draw the following conclusions: *First*, the highly exhausted bulb emits material streams which, impinging on a metallic surface, are reflected; *second*, these streams are formed of matter in some primary or elementary condition; *third*, these material streams are probably the same agent which is the cause of the electro-motive tension between metals in close proximity or actual contact, and they may possibly, to some extent, determine the energy of combination

dence of that kind is, to say the least, extremely improbable. Besides, the fact may be cited that there is always a difference of potential set up between two metal plates at some distance and in the path of the rays issuing from an exhausted bulb.

Now, since there exists an electric pressure or difference of potential between two metals in close proximity or contact, we must, when considering all the foregoing, come to the fourth conclusion, namely, that the metals emit similar streams, and I therefore anticipate that, if a sensitive film be placed between two plates, say, of magnesium and copper, a true Roentgen shadow picture would be obtained after a very long exposure in the dark. Or, in general, such picture could be secured whenever the plate is placed near a metallic or conducting body, leaving for the present the insulators out of consideration. Sodium, one of the first of the electric contact series, but not yet experimented upon, should give out more of such streams than even magnesium.

Obviously, such streams could not be forever emitted, unless there is a continuous supply of radiation from the medium in some other form; or possibly the streams which the bodies themselves emit are merely reflected streams coming from other sources. But since all investigation has strengthened the opinion advanced by Roentgen that for the production of these radiations some impact is required, the former of the two possibilities is the more probable one, and we must assume that the radiations existing in the medium and giving rise to those here considered partake something of the nature of cathodic streams.

But if such streams exist all around us in the ambient medium, the question arises, whence do they come? The only answer is: From the sun. I infer, therefore, that the sun and other sources of radiant energy must, in a less degree, emit radiations or streams of matter similar to those thrown off by an electrode in a highly exhausted inclosure. This seems to be, at this moment, still a point of controversy. According to my present convictions a Roentgen shadow picture should, with very long exposures, be obtained from all sources of radiant energy, provided the radiations are permitted first to impinge upon a metal or other body.

The preceding considerations tend to show that the lumps of matter composing a cathodic stream in the

difference was noted in any case. I therefore conclude that the matter composing the Roentgen rays does not suffer further degradation by impact against bodies. One of the most important tasks for the experimenter remains still to determine what becomes of the energy of these rays. In a number of experiments with rays reflected from and transmitted through a conducting or insulating plate, I found that only a small part of the rays could be accounted for. For instance, through a zinc plate, one-sixteenth of an inch thick, under an incident angle of 45 degrees, about two and one-half per cent were reflected and about three per cent transmitted through the plate, hence over 94 per cent of the total radiation remain to be accounted for. All the tests which I have been able to make have confirmed Roentgen's statement that these rays are incapable of raising the temperature of a body. To trace this lost energy and account for it in a plausible way will be equivalent to making a new discovery.

Since it is now demonstrated that all bodies reflect more or less, the diffusion through the air is easily accounted for. Observing the tendency to scatter through the air, I have been led to increase the efficiency of reflectors by providing not one, but separated successive layers for reflection, by making the reflector of thin sheets of metal, mica or other substances. The efficiency of mica as a reflector I attribute chiefly to the fact that it is composed of many superimposed layers which reflect individually. These many successive reflections are, in my opinion, also the cause of the scattering through the air.

In my communication to you of April 1, I have for the first time stated that these rays are composed of matter in a "primary" or elementary condition or state. I have chosen this mode of expression in order to avoid the use of the word "ether," which is usually understood in the sense of the Maxwellian interpretation, which would not be in accord with my present convictions in regard to the nature of the radiations.

An observation which might be of some interest is the following: A few years ago I described on one occasion a phenomenon observed in highly exhausted bulbs. It is a brush or stream issuing from a single electrode under certain conditions, which rotates very rapidly in consequence of the action of the earth's magnetism. Now I have recently observed

duced with a steady electrical pressure as from a battery, with the exclusion of all vibration which may occur, even in such instance, as has been pointed out by De La Rive. In my experiments I have tried to ascertain whether a greater difference between the shadows of the bones and flesh could be obtained by employing currents of extremely high frequency, but I have been unable to discover any such effect which would be dependent on the frequency of the currents, although the latter were varied between as wide limits as was possible. But it is a rule that the more intense the action the sharper the shadows obtained, provided that the distance is not too small. It is furthermore of the greatest importance for the clearness of the shadows that the rays should be passed through some tubular reflector, which renders them sensibly parallel.

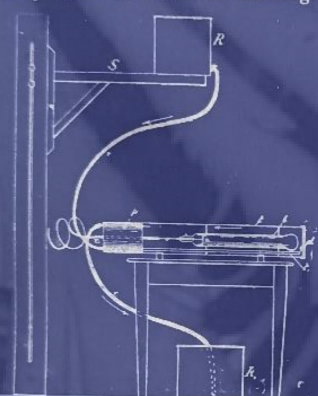
In order then to bring out as much detail as possible on a sensitive plate, we have to proceed in precisely the same way as if we had to deal with flying bullets hitting against a wall composed of parts of different density with the problem before us of producing as large as possible a difference in the trajectories of the bullets which pass through the various parts of the wall. Manifestly, this difference will be the greater the greater the velocity of the bullets; hence, in order to bring out detail, very strong radiations are required. Proceeding on this theory I have employed exceptionally thick films and developed very slowly, and in this way clearer pictures have been obtained. The importance of slow development has been first pointed out by Professor Wright, of Yale. Of course, if Professor Henry's suggestion of the use of a fluorescent body in contact with the sensitive film is made use of, the process is reduced to an ordinary quick photographic procedure, and the above consideration does not apply.

It being desirable to produce as powerful a radiation as possible, I have continued to devote my attention to this problem and have been quite successful. First of all, there existed limitations in the vacuum tube which did not permit the applying of as high a potential as I desired; namely, when a certain high degree of exhaustion was reached a spark would form behind the electrode, which would prevent straining the tube much higher. This inconvenience I have overcome entirely by making the wire leading to the electrode very long and passing it through

TESLA'S LATEST ROENTGEN RAY INVESTIGATIONS.

(Concluded from page 207.)

thick glass tube t. The tube was closed in front by a diaphragm d of pergament, and by a rubber plug P in the back. The plug was provided with two holes, into the lower one of which a glass tube t_1, reaching to very nearly the end of the bulb, was inserted. Oil of some kind was made to flow through rubber tubes r r from a large reservoir R, placed on an adjustable support S, to the lower reservoir R_1, the path of the oil being clearly observable from the drawing.



By adjusting the difference of the level between the two reservoirs it was easy to maintain a permanent condition of working. The outer glass tube t served in part as a reflector, while at the same time it permitted the observation of the bulb b during the action. The plug P, in which the conductor c was tightly sealed, was so arranged that it could be shifted in and out of the tube t, so as to vary the thickness of the oil traversed by the rays.

I have obtained some results with this apparatus which clearly show the advantage of such disposition. For instance, at a distance of 45 feet from the end of the bulb my assistants and myself could observe clearly the fingers of the hand through a screen of tungstate of calcium, the rays traversing about two and one-half inches of oil and the diaphragm d. It is practicable with such apparatus to make photographs of small objects at a distance of 40 feet, with only a few minutes exposure, by the help of Professor Henry's method. But, even without the use of a fluorescent powder, short exposures are practicable, so that I think the use of the above method is not essential for shadows has been proposed to me by Mr. E. R. Hewitt. He assumed that the absence of sharpness of the outlines in the shadows on the screen was due to the spread of the fluorescence from crystal to crystal. He proposed to avoid this by using a thin aluminum plate with many parallel grooves. Acting on this suggestion, I made some experiments with wire gauze, and, furthermore, with screens made of a mixture of a fluorescent with a non-fluorescent powder. I found that the general brightness of the screen was diminished, but that with a strong radiation the shadows appeared sharper. This idea might be found capable of useful application.

By the use of the above apparatus I have been enabled to examine much better than before the body by means of the fluorescent screen. Presently the vertebral column can be seen quite clearly, even in the lower part of the body. I have also clearly noted the outlines of the hip bones. Looking in the region of the heart I have been able to locate it unmistakably. The background appeared much brighter, and this difference in the intensity of the shadow and surrounding has surprised me. The ribs I could now see on a number of occasions quite distinctly, as well as the shoulder bones. Of course, there is no difficulty whatever in observing the bones of all limbs. I noted certain peculiar effects which I attribute to the oil. For instance, the rays passed through plates of metal over one-eighth of an inch thick, and in one instance I could see quite clearly the bones of my hand through sheets of copper, iron and brass of a thickness of nearly one-quarter of an inch. Through glass the rays seemed to pass with such freedom that, looking through the screen in a direction at right angles to the axis of the tube, the action was most intense, although the rays had to pass through a great thickness of glass and oil. A glass slab nearly one-half of an inch thick, held in front of the screen, hardly dimmed the fluorescence. When holding the screen in front of the tube at a distance of about three feet, the head of an assistant, thrust between the screen and the tube, cast but a feeble shadow. It appeared some times as if the bones and the flesh were equally transparent to the radiations passing through the oil. When very close to the bulb, the screen was illuminated through the body of an assistant so strongly that, when a hand was moved in front, I could clearly note

During my study of the behavior of oils and other liquid insulators, which I am still continuing, it has occurred to me to investigate the important effect discovered by Prof. J. J. Thomson. He announced some time ago that all bodies traversed by Roentgen radiations become conductors of electricity. I applied a sensitive resonance test to the investigation of this phenomenon in a manner pointed out in my earlier writings on high frequency currents. A secondary, preferably not in very close inductive relation to the primary circuit, was connected to the latter and to the ground, and the vibration through the primary was so adjusted that true resonance took place. As the secondary had a considerable number of turns, very small bodies attached to the free terminal produced considerable variations of potential on the latter. Placing a tube in a box of wood filled with oil and attaching it to the terminal, I adjusted the vibration through the primary so that resonance took place without the bulb radiating Roentgen rays to an appreciable extent. I then changed the conditions so that the bulb became very active in the production of the rays. The oil should have now, according to Prof. J. J. Thomson's statement, become a conductor and a very marked change in the vibration should have occurred. This was found not to be the case, so that we must see in the phenomenon discovered by J. J. Thomson only a further evidence that we have to deal here with streams of matter which, traversing the bodies, carry away electrical charges. But the bodies do not become conductors in the common acceptance of the term. The method I have followed is so delicate that a mistake is almost an impossibility.

NIKOLA TESLA.

New York, April 20.

Law Battery Company Burned Out.

The new plant of the Law Battery Company, at Cranford, N. J., was burned out on April 18. The heavy machinery was not damaged and the other losses are fully covered by insurance. The company is prepared to fill orders as usual.

New Telephone and Telegraph Companies.

CHEROKEE, IOWA—The Cherokee Telephone Company has been incor-

ELEC. REV. APR. 22, 1896

sealed, was so arranged that it could be shifted in and out of the tube *t*, so as to vary the thickness of the oil traversed by the rays.

I have obtained some results with this apparatus which clearly show the advantage of such disposition. For instance, at a distance of 45 feet from the end of the bulb my assistants and myself could observe clearly the fingers of the hand through a screen of tungstate of calcium, the rays traversing about two and one-half inches of oil and the diaphragm *d*. It is practicable with such apparatus to make photographs of small objects at a distance of 40 feet, with only a few minutes exposure, by the help of Professor Henry's method. But, even without the use of a fluorescent powder, short exposures are practicable, so that I think the use of the above method is not essential for quick procedure. I rather believe that in the practical development of this principle, if it shall be necessary, Professor Salvioni's suggestion of a fluorescent emulsion, combined with a film, will have to be adopted. This is bound to give better results than an independent fluorescent screen, and will very much simplify the process. I may say, however, that, since my last communication, considerable improvement has been made in the screens. The manufacturers of Edison's tungstate of calcium are now furnishing screens which give fairly clean pictures. The powder is fine and it is more uniformly distributed. I consider, also, that the employment of a softer and thicker paper than before is of advantage. It is just to remark that the tungstate of calcium has also proved to be an excellent fluorescent in the bulb. I tested its qualities for such use immediately and find it so far unexcelled. Whether it will be so for a long time remains to be seen. News reaches us that several fluorescent bodies, better than the cyanides, have been discovered abroad.

Another improvement with a view of increasing the sharpness of the ... to pass with such freedom that, looking through the screen in a direction at right angles to the axis of the tube, the action was most intense, although the rays had to pass through a great thickness of glass and oil. A glass slab nearly one-half of an inch thick, held in front of the screen, hardly dimmed the fluorescence. When holding the screen in front of the tube at a distance of about three feet, the head of an assistant, thrust between the screen and the tube, cast but a feeble shadow. It appeared some times as if the bones and the flesh were equally transparent to the radiations passing through the oil. When very close to the bulb, the screen was illuminated through the body of an assistant so strongly that, when a hand was moved in front, I could clearly note the motion of the hand through the body. In one instance I could even distinguish the bones of the arm.

Having observed the extraordinary transparence of the bones in some instances, I at first surmised that the rays might be vibrations of high pitch, and that the oil had in some way absorbed a part of them. This view, however, became untenable when I found that at a certain distance from the bulb I obtained a sharp shadow of the bones. This latter observation led me to apply usefully the screen in taking impressions on the plate. Namely, in such case it is of advantage to first determine by means of the screen the proper distance at which the object is to be placed before taking the impression. It will be found that often the image is much clearer at a greater distance. In order to avoid any error when observing with the screen, I have surrounded the box with thick metal plates, so as to prevent the fluorescence, in consequence of the radiations, reaching the screen from the sides. I believe that such an arrangement is absolutely necessary if one wishes to make correct observations.

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ELEC. REV. APR. 22, 1896

permitted first to impinge upon a metal or other body.

The preceding considerations tend to show that the lumps of matter composing a cathodic stream in the bulb are broken up into incomparably smaller particles by impact against the wall of the latter, and, owing to this, are enabled to pass into the air. All evidence which I have so far obtained points rather to this than to the throwing off of particles of the wall itself under the violent impact of the cathodic stream. According to my convictions, then, the difference between Lenard and Roentgen rays, if there be any, lies solely in this, that the particles composing the latter are incomparably smaller and possess a higher velocity. To these two qualifications I chiefly attribute the non-deflectibility by a magnet which I believe will be disproved in the end. Both kinds of rays, however, affect the sensitive plate and fluorescent screen, only the rays discovered by Roentgen are much more effective. We know now that these rays are produced under certain exceptional conditions in a bulb, the vacuum being extremely high, and that the range of greatest activity is rather small.

I have endeavored to find whether the reflected rays possess certain distinctive features, and I have taken pictures of various objects with this purpose in view, but no marked

or stream issuing from a single electrode under certain conditions, which rotates very rapidly in consequence of the action of the earth's magnetism. Now I have recently observed this same phenomenon in several bulbs which were capable of impressing the sensitive film and fluorescent screen very strongly. As the brush is rapidly twirling around I have conjectured that perhaps also the Lenard and Roentgen streams are rotating under the action of the earth's magnetism, and I am endeavoring to obtain an evidence of such motion by studying the action of a bulb in various positions with respect to the magnetic axis of the earth.

In so far as the vibrational character of the rays is concerned, I still hold that the vibration is merely that which is conditioned by the apparatus employed. With the ordinary induction coil we have almost exclusively to deal with a very low vibration impressed by the commutating device or brake. With the disruptive coil we usually have a very strong superimposed vibration in addition to the fundamental one, and it is easy to trace sometimes as much as the fourth octave of the fundamental vibration. But I can not reconcile myself with the idea of vibrations approximating or even exceeding those of light, and think that all these effects could be as well pro-

which would prevent straining the tube much higher. This inconvenience I have overcome entirely by making the wire leading to the electrode very long and passing it through a narrow channel, so that the heat from the electrode could not cause the formation of such sparks. Another limitation was imposed by streamers which would break out at the end of the tube when the potential was excessive. This latter inconvenience I have overcome either by the use of a cold blast of air along the tube, as I have mentioned before, or else by immersion of the tube in oil. The oil, as it is now well known, is a means of rendering impossible the formation of streamers by the exclusion of all air. The use of the oil in connection with the production of these radiations has been early advocated in this country by Professor Trowbridge. Originally I employed a wooden box made thoroughly tight with wax and filled with oil or other liquid, in which the tube was immersed. Observing certain specific actions, I modified and improved the apparatus, and in my later investigations I have employed an arrangement as shown in the annexed cut. A bulb *b*, of the kind described before, with a leading-in wire and neck much longer than here shown, was inserted into a large and

(Concluded on page 211.)

ELEC. REV. (N.Y.) APR. 22, 1896

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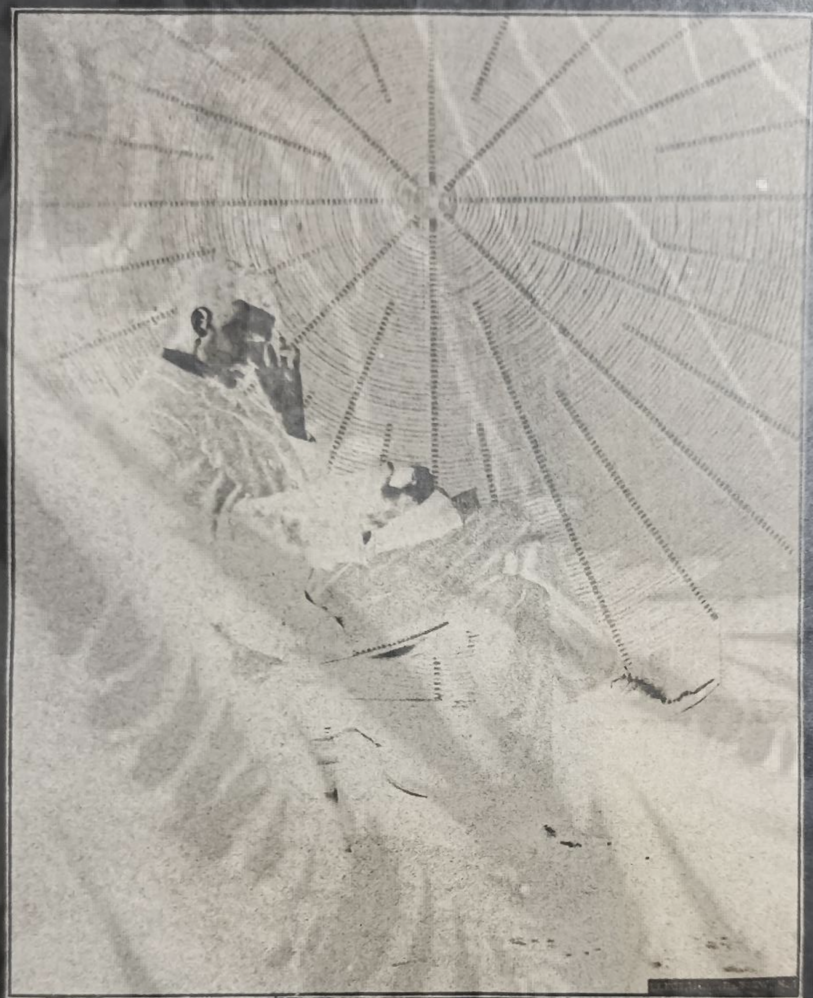
justified to draw the following conclusions: *First*, the highly exhausted bulb emits material streams which, impinging on a metallic surface, are reflected; *second*, these streams are formed of matter in some primary or elementary condition; *third*, these material streams are probably the same agent which is the cause of the electro-motive tension between metals in close proximity or actual contact, and they may possibly, to some extent, determine the energy of combination of the metals with oxygen; *fourth*, every metal or conductor is more or less a source of such streams; *fifth*, these streams or radiations must be produced by some radiations which exist in the medium; and *sixth*, streams resembling the cathodic must be emitted by the sun and probably also by other sources of radiant energy, such as an arc light or Bunsen burner.

The first of these conclusions, assuming the above-cited fact to be correct, is evident and uncontrovertible. No theory of vibration of any kind would account for this singular relation between the powers of reflection and electric properties of the metals. Streams of projected matter coming in actual contact with the reflecting metal surface afford the only plausible explanation.

The second conclusion is likewise obvious, since no difference whatever is observed by employing various qualities of glass for the bulb, electrodes of different metals and any kind of residual gases. Evidently, whatever the matter constituting the streams may be, it must undergo a change in the process of expulsion, or, generally speaking, projection—since the views in this regard still differ—in such a way as to lose entirely the characteristics which it possessed when forming the electrode, or wall of the bulb, or the gaseous contents of the latter.

The existence of the above relation between the reflecting and contact series forces us likewise to the third conclusion, because a mere coinci-

of his warmest friend, Mr. E. D. Adams; and as to the queer coil to



Tesla in His Laboratory—Portrait Obtained by an Exposure of Two Seconds to the Light of a Single Vacuum Tube without Electrodes, Having a Volume of About 90 Cubic Inches, Giving Approximately a Light of 250 Candle-Power—Photographed by Tonnelé & Co. Copyrighted by the "Electrical Review."

his left, Mr. Tesla hesitatingly remarked that it was the object "dearest of all in his laboratory," having been a most valuable instrument in his many-sided investigations.

Mr. Tesla added, good humoredly, that, had it not been for the extraordinary manner in which the photograph was taken he would ...

Street Journal recently, and stated that negotiations had been under way for the removal of the company's works from Schenectady, but that these had been dropped for the present. Mr. Coffin further stated that the patent agreement with the Westinghouse company will go into effect June 1. It will not change the style or character of apparatus manufactured at the works in any substantial respect. The patent agreement has been under consid-

TESLA'S IMPORTANT ADVANCES.

HIS REMARKABLE ACHIEVEMENTS IN VACUUM TUBE LIGHTING.

A representative of the ELECTRICAL REVIEW visited the laboratory of Mr. Tesla last week and found him engaged in putting the final touches to certain improvements in vacuum tube illumination. He was enthusiastic as to the results arrived at to such a degree that he expressed his positive confidence as to having made very important advances.

While reluctant to speak at present extensively on the subject of his most recent investigations, he authorized the statement to the effect that he has been most successful in several lines of work he has been following up for a long time, only temporarily interrupted by the lamented destruction of his laboratory by fire about a year ago.

When asked about his often-mentioned oscillator he said that a commercial machine is now being completed with which he expects to show the superiority of this mode of generating electricity.

He further stated with evident elation that in the study of the Roentgen phenomenon he has made great progress, so much so that he is now able to perceive through an Edison improved Roentgen-screen, recently purchased from Aylsworth & Jackson, of this city, the heart of an assistant so clearly as to note its expansions and contractions. In some instances he could locate evident defects in the lungs of a number of persons.

As to his continuous efforts to improve his system of lighting by vacuum tubes, with which he has been identified during a number of years, Tesla said that he has been more successful than he had ever dared to hope. His

faintly shown in the reproduction on this page. The photograph was made by Tonnelé & Company, artists' photographers, who aided Mr. Tesla in his attempts to photograph by the light of phosphorescent tubes about two years ago.

When asked, Mr. Tesla said, in explanation of the picture, speaking with deep feeling, that the volume he was reading was one of the "Scientific Papers," of Maxwell, given to him as a token of friendship by Professor Dewar; the chair a gift of his warmest friend, Mr. E. D. Adams; and as to the queer coil to

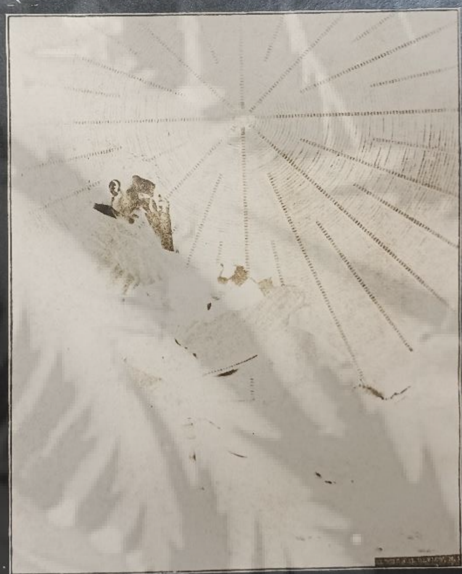
his left, Mr. Tesla hesitatingly re-

General Electric Company's Annual Meeting.

The annual meeting of the General Electric Company was held at Schenectady, N. Y., on May 12. The representation of stock was 201,000 shares. George Foster Peabody was elected a director in place of Thomas K. Cummings, Jr. The balance of the old board of directors was re-elected. Only routine business was transacted and the question of capital impairment was not brought up.

President Charles A. Coffin, of the General Electric Company, was seen by one of the editors of the *Wall Street Journal* recently, and stated that negotiations had been under way

for the removal of the company's



TESLA IN HIS LABORATORY—PORTRAIT OBTAINED BY AN EXPOSURE OF TWO SECONDS TO THE LIGHT OF A SINGLE VACUUM TUBE WITHOUT ELECTRODES, HAVING A VOLUME OF ABOUT 90 CUBIC INCHES, GIVING APPROXIMATELY A LIGHT OF 250 CANDLE-POWER—PHOTOGRAPHED BY TONNELÉ & CO. COPYRIGHTED BY THE "ELECTRICAL REVIEW."

[VAC]UUM TUBE LIGHTING.

The Electrical Review has from the outset closely followed the promising work of Nikola Tesla. We had the privilege of announcing in 1886, for the first time, Tesla's investigations in a system of electric lighting. Early in 1888 we were the first to announce his epochal discovery of the multiphase system of power transmission, and since that time it has been our pleasant duty to keep our readers well informed on the various subjects of his important researches, of which we only mention his latest contributions to the great discoveries of Roentgen, which were exclusively published in our columns. It is, therefore, no small satisfaction for us to now first record another significant advance of this indefatigable worker. Ever since Tesla showed in his memorable lecture before the American Institute of Electrical Engineers, five years ago, the fascinating experiments with vacuum tubes, he has untiringly labored on, simplifying and improving his methods, not for a moment diverted by other tasks — nor even discouraged by so great a calamity as the recent destruction of his laboratory—from the problem of producing an efficient and practical system of electrical illumination.

No more impressive result of Tesla's earnest efforts could be shown than that which is outlined in our present issue. The portrait of the great inventor, which, especially in view of the extraordinary way in which it was obtained will not fail to interest the scientific world, is a striking illustration of what he has done. Surely, since he has produced a vacuum tube which is capable of supplying any volume of light desired, even more than a powerful arc light, we can not hesitate to express our positive conviction that the introduction of a more perfect illuminant is near at hand.

May 20, 189[illegible]

TESLA'S IMPORTANT ADVAN[...]

HIS REMARKABLE ACHIEVEMENT[...] VACUUM TUBE LIGHTING.[...]

Tesla in His Laborator[...] Seconds to the Light [...] Having a Volume of [...] Light of 250 Candle-[...] righted by the "Elec[...]

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HIS REMARKABLE ACHIEVEMENTS IN VACUUM TUBE LIGHTING.

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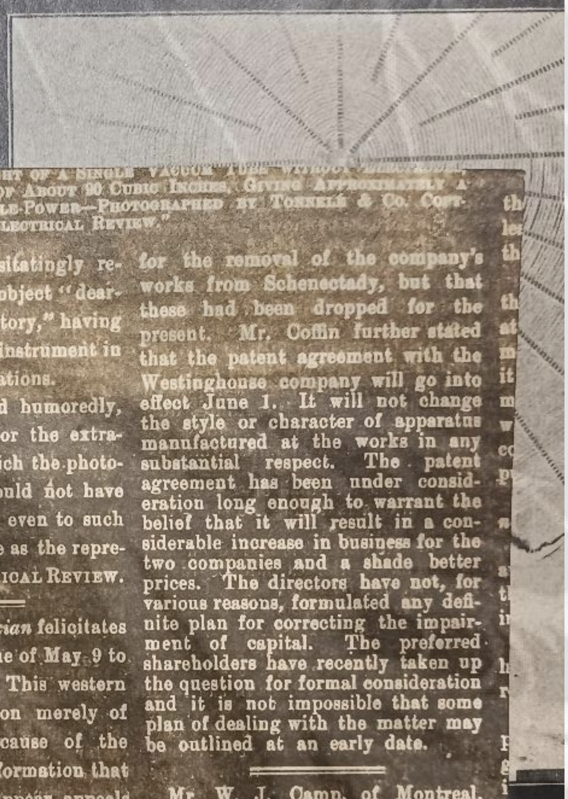

tubes, with which he has been identified during a number of years, Tesla said that he has been more successful than he had ever dared to hope. His methods of conversion from ordinary to high-frequency currents are rendered simple in the extreme, the devices are thoroughly reliable and require no attention. Last, but most important of all, he has succeeded in increasing the candle-power of the tubes to practically any intensity desired.

A remarkable and most telling result of the advances he has made in the last direction is a portrait, which he has reluctantly allowed us to use, and which was obtained by *two seconds'* exposure to the light of a *single vacuum tube* of small dimensions. Tesla stated further that photographs obtained by the light of such powerful tubes show an amount of detail which no picture taken by the sun or flash light is capable of disclosing. This feature is only

SECONDS TO THE LIGHT OF A SINGLE VACUUM TUBE WITHOUT ... HAVING A VOLUME OF ABOUT 90 CUBIC INCHES, GIVING APPROXIMATELY A LIGHT OF 250 CANDLE-POWER—PHOTOGRAPHED BY TONNELÉ & CO. COPYRIGHTED BY THE "ELECTRICAL REVIEW."

his left, Mr. Tesla hesitatingly remarked that it was the object "dearest of all in his laboratory," having been a most valuable instrument in his many-sided investigations.

Mr. Tesla added, good humoredly, that, had it not been for the extraordinary manner in which the photograph was taken, he would not have given this explanation even to such an important personage as the representative of the ELECTRICAL REVIEW.

The *Western Electrician* felicitates itself on getting its issue of May 9 to New York on May 2. This western enterprise is a question merely of dating ahead—and because of the news and up-to-date information that does not, but should, appear appeals solely to the amiable minds to be found in the editorial office of our blue-countenanced contemporary.

for the removal of the company's works from Schenectady, but that these had been dropped for the present. Mr. Coffin further stated that the patent agreement with the Westinghouse company will go into effect June 1. It will not change the style or character of apparatus manufactured at the works in any substantial respect. The patent agreement has been under consideration long enough to warrant the belief that it will result in a considerable increase in business for the two companies and a shade better prices. The directors have not, for various reasons, formulated any definite plan for correcting the impairment of capital. The preferred shareholders have recently taken up the question for formal consideration and it is not impossible that some plan of dealing with the matter may be outlined at an early date.

Mr. W. J. Camp, of Montreal, electrician of the Canadian Pacific Telegraph, was a New York visitor last week, conferring with Electrician F. W. Jones, of the Postal Telegraph.

was obtained will not fail to interest the scientific world, is a striking illustration of what he has done. Surely, since he has produced a vacuum tube which is capable of supplying any volume of light desired, even more than a powerful arc light, we can not hesitate to express our positive conviction that the introduction of a more perfect illuminant is near at hand.

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HAVING A VOLUME OF ABOUT LIGHT OF 250 CANDLE-POWE RIGHTED BY THE "ELECTRICA

his left, Mr. Tesla hesitating

hood of the phosphorescent patch was brightly illuminated, the outlines being entirely indistinct. Receding now with the screen from the bulb, the strongly illuminated spot became smaller and the outlines sharper, until, when the point *o* was reached, the luminous part had dwindled down to a small point. Moving the screen a few millimetres beyond *o* caused a small dark spot to appear, which widened into a circle and became larger and larger in the same measure as the distance from the bulb was increased (see S), until, at a sufficiently large distance, the dark circle covered the entire screen. This experiment illustrated in a beautiful way the propagation in straight lines, which Roentgen originally proved by pinhole photographs. But, besides this, an important point was noted; namely, that the fluorescent glass wall emitted practically no rays, whereas, had the platinum not been present, it would have been, under similar conditions, an efficient source of the rays, for the glass, even by weak excitation of the bulb, was strongly heated. I can only explain the absence of the radiation from the glass by assuming that the matter proceeding from the surface of the platinum sheet was already in a finely divided state when it reached the glass wall. A remarkable fact is, also, that, at least by a weak excitation of the bulb, the edges of the dark circle were very sharp, which speaks strongly against diffusion. By exciting the bulb very strongly, the background became brighter and the shadow S fainter, though it continued to be plainly visible even then.

From the preceding it is evident that, by a suitable construction of the bulb, the rays emanating from the latter may be concentrated upon any small area at some distance, and a practical advantage may be taken of this fact when producing impressions upon a plate or examining bodies by means of a fluorescent screen.

N. Tesla.

New York, July 1, 1896.

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way with train locomotives.

The articles of agreement for
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Until then, it is said, the matter
wait.

The court decides, at Trenton, t
trolley companies may erect poles
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was that of Mrs. Washington
Roebling against the Trenton Tract
Company. A trolley pole was erec
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Mrs. Roebling can show special d
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The Flat Top Central Elec
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illustrate his scientific hobbies. A command of photography is another of his accomplishments.

An insulating material for wires is manufactured by Anderson, of Stockholm, by treating a fatty oil—such as resin oil—with 20 to 30 per cent of concentrated sulphuric acid at a low temperature. To this is added cellulose or moistened cotton, and the whole is heated to 110 degrees centigrade, and pulverized sulphur is added, which is followed by a reaction which completely changes the consistency of the material. A further large quantity of sulphur is added, and the material is then poured into cold water, after which it is rolled between cylinders and combined with rubber, gutta-percha, resin or paraffine, according to the purpose for which it is to be used.

There have been several peculiar trolley accidents in Brooklyn recently. In one instance a young lady had her jawbone broken by the end of the pole of a beer wagon, tearing her face horribly. Again, a boy, frightened by the burning out of a fuse, jumped off the car and was severely cut. He is suing for $5,000 damages.

One Thomas S. Wentworth is president of the South Peacock Mining Company, organized in Berwick, Me., with a capital of $500,000, of which $35 is paid in, to carry on a mining and electric light and power plant. This Peacock company can't do much strutting until some more cash is paid in.

The "Bridging Bell" Patent.

To the Editor of Electrical Review:

Will you kindly inform me through the columns of your valuable paper or by mail whether the "bridge bell" or method of connecting telephones "in multiple" is covered by patent?

I have seen many inquiries of this kind in your paper and, therefore, venture to ask this.

J. W. Lord.

Limerick, Me., June 30.

This patent is owned by the Western Electric Company, New York and Chicago.

TESLA DESCRIBES AN INTERESTING FEATURE OF THE X-RAY RADIATIONS.

To the Editor of Electrical Review:

The following observations, made with bulbs emitting Roentgen radiations, may be of value in throwing additional light upon the nature of

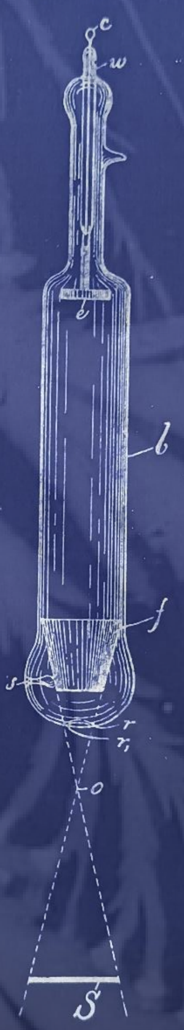

Diagram Illustrating Tesla's Experiment.

these radiations, as well as illustrating better properties already known. In the main these observations agree with the views which have forced themselves upon my mind from the outset, namely, that the rays consist of streams of minute material particles projected with great velocity. In numerous experiments I have found that the matter which, by impact within the bulb, causes the formation of the rays, may come from either of the electrodes. Inasmuch as the latter are by continued use disintegrated to a marked degree, it seems more plausible to assume that the projected matter consists of parts of the electrodes themselves rather than of the residual gas. However, other observations, upon which I can not dwell at present, lead to this conclusion. The lumps of projected matter are by impact further disintegrated into particles so minute as to be able to pass through the walls of the bulb, or else they tear off such particles from the walls, or generally bodies, against which they are projected. At any rate, an impact and consequent shattering seems absolutely necessary for the production of Roentgen rays. The vibration, if there be any, is only that which is impressed by the apparatus, and the vibrations can only be longitudinal.

The principal source of the rays is invariably the place of first impact within the bulb, whether it be the anode, as in some forms of tube, or an inclosed insulated body, or the glass wall. When the matter thrown off from an electrode, after striking against an obstacle, is thrown against another body, as the wall of the bulb, for instance, the place of second impact is a very feeble source of the rays.

These and other facts will be better appreciated by referring to the annexed figure, in which a form of tube is shown used in a number of my experiments. The general form is that described on previous occasions. A single electrode *e*, consisting of a massive aluminium plate, is mounted on a conductor *c*, provided with a glass wrapping *w* as usual, and sealed in one of the ends of a straight tube *b*, about five centimetres in diameter and 30 centimetres long. The other end of the tube is blown out into a thin bulb of a slightly larger diameter, and near this end is supported on a

glass stem s a funnel f of thin platinum sheet. In such bulbs I have used a number of different metals for impact with a view of increasing the intensity of the rays and also for the purpose of reflecting and concentrating them. Since, however, in a later contribution, Professor Roentgen has pointed out that platinum gives the most intense rays, I have used chiefly this metal, finding a marked increase in the effect upon the screen or sensitive plate. The particular object of the presently described construction was to ascertain whether the rays generated at the inner surface of the platinum funnel f would be brought to a focus outside of the bulb, and further, whether they would proceed in straight lines from that point. For this purpose the apex of the platinum cone was arranged to be about two centimetres outside of the bulb at o.

When the bulb was properly exhausted and set in action, the glass wall below the funnel f became strongly phosphorescent, but not uniformly, as there was a narrow ring $r\ r$ on the periphery brighter than the rest, this ring being evidently due to the rays reflected from the platinum sheet.

Placing a fluorescent screen in contact or quite close to the glass wall below the funnel, the portion of the screen in the immediate neighborhood of the phosphorescent patch was brightly illuminated, the outlines being entirely indistinct. Receding now with the screen from the bulb, the strongly illuminated spot became smaller and the outlines sharper, until, when the point o was reached, the luminous part had dwindled down to a small point. Moving the screen a few millimetres beyond o caused a small dark spot to appear, which widened into a circle and became larger and larger in the same measure as the distance from the bulb was increased (see S), until, at a sufficiently large distance, the dark circle covered the entire screen. This experiment illustrated in a beautiful way the propagation in straight lines, which Roentgen originally proved by pinhole photographs. But, besides this, an important point was noted; namely, that the fluorescent glass wall emitted practically no rays, whereas, had the platinum not been present, it would have been, under similar

...reating a fatty oil ...
...-with 20 to 30 per cent of
...ted sulphuric acid at a low
...re. To this is added cellu-
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...Bridging Bell" Patent.

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...u kindly inform me through
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J. W. LORD.

additional light upon the nature of

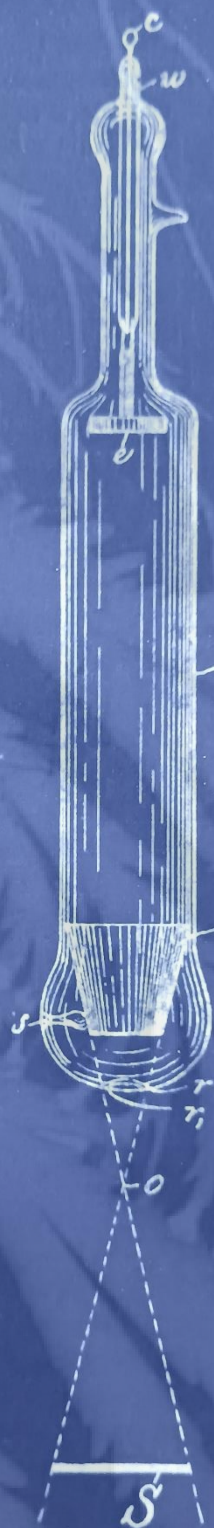

DIAGRAM ILLUSTRATING TESLA'S EXPERIMENT.

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TESLA ON THE NATURE OF THE ROENTGEN RAYS.

In our present issue we publish another important communication from Mr. Tesla in regard to the Roentgen rays. Mr. Tesla has worked ceaselessly, and in his articles, exclusively published in our columns, he has made most valuable contributions to the knowledge of this fascinating subject. His opinions carry the greater weight as they are supported by a mass of experimental evidence, and as his insight into many phenomena has proved to be true. What services has he not rendered to science and industry merely by his demonstrations of the action of air or gases in condensers and high-tension transformers! His present contribution is, in part, a summing up of the observations already made by him, and is particularly important in this, that it substantiates the ideas originally expressed by Professor Roentgen.

Mr. Tesla brings forward many convincing arguments to show that these rays consist of streams of matter in some primary condition, which is, to a certain extent, equivalent to saying that they are streams of ether into which the matter is dissolved by the violent impact.

There is thus opened up a wonderful possibility of transformation of matter into its primary constituents, never before contemplated or thought possible, and it is safe to say that a more absorbing subject for study and investigation could not be found in physical science.

TO STOP CUTTING PRICES.

The incandescent lamp manufacturers, after two or three years of cutting of prices, have concluded that it would be better to maintain a regu-

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WAY NOTES.

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ROENTGEN RAYS OR STREAMS.

(Concluded from page 79.)

place them as closely together as possible. They also showed the fallacy of comparing results obtained with different bulbs.

V—ACTION ON THE FILMS.

Many experiments with films of different thicknesses show that decidedly more detail is obtainable with a thick film than with a thin one. This appears to me to be a further evidence in support of the above views, as the result can be easily explained when considering the preceding remarks.

VI — THE BEHAVIOR OF VARIOUS BODIES IN REFLECTING THE RAYS,

on which I have previously dwelt, will, if verified by other experimenters, leave no room for a doubt that the radiations are streams of some matter, or possibly of ether, as before observed.

VII—THE ENTIRE ABSENCE OF REFRACTION

and other features possessed by the light waves has, since Roentgen's announcement, not yet been satisfactorily explained. A trace at least of such an effect would be found if the rays were transverse vibrations.

VIII—THE DISCHARGE OF CONDUCTORS

by the rays shows, in so far as I have been able to follow the researches of others, that the electrical charge is taken off by the bodily carriers. It is also found that the opacity plays an important part, and the observations are mostly in accord with the above views.

IX—THE SOURCE OF THE RAYS

is, I find, always the place of the first impact of the cathodic stream, a second impact producing little or no rays. This fact would be difficult to account for unless streams of matter are assumed to exist.

X—SHADOWS IN SPACE OUTSIDE OF THE BULB.

An almost crucial test of the existence of material streams is afforded by the formation of shadows in space at a distance from the bulb, to which I have called attention quite recently. I will presently refer to my preceding communication on this subject, and will only point out that such shadows could not be formed under the conditions described, except by streams of matter.

XI—ALL BODIES ARE TRANSPARENT TO VERY STRONG RAYS

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LWAY NOTES.

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XI—ALL BODIES ARE TRANSPARENT TO VERY STRONG RAYS.

Experiments establish this fact beyond any doubt. With very intense radiations, I obtain, easily, impressions through what may be considered a great thickness of any metal. It is impossible to explain this on any theory of transverse vibrations. We can show how one or other body might allow the rays to pass through, but such explanations are not applicable to *all* bodies without exception. On the contrary, assuming material streams, such a result is unavoidable.

A great many other observations and facts might be added to the above, as further evidence in support of the above views. I have noted certain peculiarities of bodies obstructing a cathodic stream within the bulb. I have observed that the same rays are produced at all degrees of exhaustion and using bodies of vastly different physical properties, and have found a number of features in regard to the pressure, the vacuum, the residual gas, the material of the electrode, etc., all of which observations are more or less in accord with what I have stated before. I hope, however, that there is enough in the present lines to enlist the attention of others.

NIKOLA TESLA.

New York, August 11, 1896.

[illegible]able in free air, even without the employment of a vacuum bulb, simply by the use of very high potentials, suitable for imparting to the molecules of the air or other particles a sufficiently high velocity. In reality, such puffs or jets of particles are formed in the vicinity of every highly charged conductor, the potential of which is rapidly varying, and I have shown that, unless they are prevented, they are fatal to every condenser or high-potential transformer, no matter how thick the insulation. They also render practically valueless any estimate of the period of vibration of an electro-magnetic system by the usual mode of calculation or measurement in a static condition in all cases in which the potential is very high and the frequency excessive.

It is significant that, with these and other facts before him, Roentgen inclined to the conviction that the rays he discovered were longitudinal waves of ether.

After a long and careful investigation, with apparatus excellently suited for the purpose, capable of producing impressions at great distances, and after examining the results pointed out by other experimenters, I have come to the conclusion which I have already intimated in my former contributions to your esteemed journal, and which I now find courage to pronounce without hesitation, that the original hypothesis of Roentgen will be confirmed in two particulars: first, in regard to the longitudinal character of the disturbances; second, in regard to the medium concerned in their propagation. The present expression of my views is made solely for the purpose of preserving a faithful record of what, to my mind, appears to be the true interpretation of these new and important manifestations of energy.

Recent observations of some dark radiations from novel sources by Becquerel and others, and certain deductions of Helmholtz, seemingly applicable to the explanation of the peculiarities of the Roentgen rays, have given additional weight to the arguments on behalf of the theory tube. The exit from the latter is, however, the more likely to occur, as the lumps of matter must be shattered into still much smaller particles by the impact. From my experiments on reflection of the Roentgen rays, before reported, which, with powerful radiations, may be shown to exist under all angles of incidence, it appears that the lumps or molecules are indeed shattered into fragments or constituents so small as to make them lose entirely some physical properties possessed before the impact. Thus, the material composing the electrode, the wall of the bulb or obstruction of any kind placed within the latter, are of absolutely no consequence, except in so far as the intensity of the radiations is concerned. It also appears, as I have pointed out, that no further disintegration of the lumps is attendant upon a second impact. The matter composing the cathodic stream is, to all evidence, reduced to matter of some primary form, heretofore not known, as such velocities and such violent impacts have probably never been studied or even attained before these extraordinary manifestations were observed. Is it not possible that the very ether vortexes which, according to Lord Kelvin's ideal theory, compose the lumps, are dissolved, and that in the Roentgen phenomena we may witness a transformation of ordinary matter into ether? It is in this sense that, I think, Roentgen's first hypothesis will be confirmed. In such case there can be, of course, no question of waves other than the longitudinal assumed by him, only, in my opinion, the frequency must be very small—that of the electro-magnetic vibrating system—generally not more than a few millions a second. If such process of transformation does take place, it will be difficult, if not impossible, to determine the amount of energy represented in the radiations, and the statement that this amount is very small should be received with some caution.

As to the rays exhaustively studied by Lennard, which have proved to be the nucleus of these great realizations, I hold them to be true cathodic streams, projected through the wall of

Upon the disappearance of the first fluorescence the rarefaction increases slowly, this being a necessary result of particles being projected from the electrode and fastening themselves upon the wall. These particles absorb a large portion of the residual gas. The latter can be again freed by the application of heat to the bulb or otherwise. So much of the effects observed by these investigators. In the instance observed by myself, there must be actual expulsion of matter, and for this speak following facts: (a) the exhaustion is quicker when the glass is thin; (b) when the potential is higher; (c) when the discharges are more sudden; (d) when there is no obstruction within the bulb; (e) the exhaustion takes place quickest with an aluminum or platinum electrode, the former metal giving particles moving with greatest velocity, the latter particles of greatest weight; (f) the glass wall, when softened by the heat, does not collapse, but bulges outwardly; (g) the exhaustion takes place, in some cases, even if a small perceptible hole is pierced through the glass; (h) all causes tending to impart a greater velocity to the particles hasten the process of exhaustion.

II—RELATION BETWEEN OPACITY AND DENSITY.

The important fact pointed out early by Roentgen and confirmed by subsequent research, namely, that a body is the more opaque to the rays the denser it is, can not be explained as satisfactorily under any other assumption as that of the rays being streams of matter, in which case such simple relation between opacity and density would necessarily exist. This relation is the more important in its bearing upon the nature of the rays, as it does not at all exist in light-giving vibrations, and should consequently not be found to so marked a degree and under *all conditions with vibrations*, presumably similar to and approximating in frequency the light vibrations.

III—DEFINITION OF SHADOWS ON SCREEN OR PLATE.

When taking impressions or observ-

bones grows deeper, and in this neighborhood a place can be found at which the definition of the shadow is clearest. If the distance is still further continually increased, the detail is lost, and finally only a vague shadow is perceptible, showing apparently the outlines of the hand.

This often-noted fact disagrees entirely with any theory of transverse vibrations, but can be easily explained on the assumption of material streams. When the hand is near and the velocity of the stream of particles very great, both bone and flesh are easily penetrated, and the effect due to the difference in the retardation of the particles passing through the heterogeneous parts can not be observed. The screen can fluoresce only up to a certain limited intensity, and the film can be affected only to a certain small degree. When the distance is increased, or, what is equivalent, when the intensity of the radiation is reduced, the more resisting bones begin to throw the shadow first. Upon a further increase of the distance the flesh begins likewise to stop enough of the particles to leave a trace on the screen. But in all cases, at a certain distance, manifestly that which under the conditions of the experiment gives the greatest difference in the trajectories of the particles within *the range perceptible on the screen or film*, the clearest shadow is secured.

IV—THE RAYS ARE ALL OF ONE KIND.

The preceding explains the apparent existence of rays of different kind; that is, of different rates of vibration, as it is asserted. In my opinion, the velocity and possibly the size of the particles both are different, and this fully accounts for the discordant results obtained in regard to the transparency of various bodies to these rays. I found, for example, in many cases that aluminum was less transparent than glass, and in some instances brass appeared to be very transparent as compared with other metallic bodies. Such observations showed that it was necessary, in making the comparison, to take rigorously equal thicknesses of the bodies and

(Concluded on page 55.)

Roentgen Rays or Streams.

To the Editor of the Electrical Review:

In the original report of his epochal discoveries, Roentgen expressed his conviction that the phenomena he observed were due to certain novel disturbances in the ether. This opinion deserves to be considered the more as it was probably formed in the first enthusiasm over the revelations, when the mind of the discoverer was under the spell of a much deeper insight into the nature of things.

It was known since long ago that certain dark radiations, capable of penetrating opaque bodies, existed, and when the rectilinear propagation, the action on a fluorescent screen and on a sensitive film was noted, an obvious and unavoidable inference was that the new radiations were transverse vibrations, similar to those known as light. On the other hand, it was difficult to resist certain arguments in favor of the less popular theory of material particles, especially as, since the researches of Lennard, it has become very probable that material streams, resembling the cathodic, existed in free air. Furthermore, I myself have brought to notice the fact that similar material streams —which were subsequently, upon Roentgen's announcement, found capable of producing impressions on a sensitive film—were obtainable in free air, even without the employment of a vacuum bulb, simply by the use of very high potentials, suitable for imparting to the molecules of the air or other particles a sufficiently high velocity. In reality, such puffs or jets of particles are formed in the vicinity of every highly charged conductor, the potential of which is rapidly varying, and I have shown that, unless they are prevented, they are fatal to every condenser or high-potential transformer, no matter how thick the insulation. They also [illegible] of transverse vibrations, and accordingly this interpretation of the phenomena is held in favor. But this view is still of a purely speculative character, being, as it is at present, unsupported by any conclusive experiment. Contrarily, there is considerable experimental evidence that some matter is projected with great velocity from the bulbs, this matter being in all probability the only cause of the actions discovered by Roentgen.

There is but little doubt at present that a cathodic stream within a bulb is composed of small particles of matter, thrown off with great velocity from the electrode. The velocity probably attained is estimable and fully accountable for the mechanical and heating effects produced by the impact against the wall or obstacle within the bulb. It is, furthermore, an accepted view that the projected lumps of matter act as inelastic bodies, similarly to ever so many small lead bullets. It can be easily shown that the velocity of the stream may be as much as 100 kilometers a second, or even more, at least in bulbs with a single electrode, in which the practicable vacua and potentials are much higher than in the ordinary bulbs with two electrodes. But, now, matter moving with such great velocity must surely penetrate great thicknesses of the obstruction in its path, if the laws of mechanical impact are at all applicable to a cathodic stream. I have presently so much familiarized myself with this view that, if I had no experimental evidence, I would not question the fact that some matter is projected through the thin wall of a vacuum tube. The exit from the latter is, however, the more likely to occur, as the lumps of matter must be shattered into still much smaller particles by the impact. From my experiments on reflection of the Roentgen rays, before reported, which, with powerful radiations, may be shown to exist under all angles of incidence, it appears that the lumps or molecules are indeed shattered into fragments or constituents so small as to make them lose entirely some physical properties possessed before the impact. Thus, the material composing the electrode, the [illegible] the tube. Their deflectibility by a magnet shows to my mind simply that they differ but little from those within the bulb. The lumps of matter are probably large and the velocity small as compared with that of the Roentgen rays. They should, however be capable in a minor degree of all the actions of the latter. These actions I consider to be purely mechanical and obtainable by other means. So, for instance, I think that if a gun loaded with mercury were fired through a thin board, the projected mercury vapor would cast a shadow of an object upon a [illegible] especially sensitive to mercurial [illegible], or upon a screen of material capable of being rendered fluorescent by such impact.

The following observations made by myself and others speak more or less for the existence of the streams of matter.

I.—PHENOMENA OF EXHAUSTION.

On this subject I have expressed myself on another occasion. It is only necessary to once more point out that the effect observed by me should not be confounded with that noted by Spottiswoode and Crookes. I explain the latter phenomenon as follows: The first fluorescence appearing when the current is turned on, is due to some organic matter almost always introduced in the bulb in the process of manufacture. A minute layer of such matter on the wall produces invariably this first fluorescence, and the latter never takes place when the bulb has been exhausted under application of a high degree of heat or when the organic matter is otherwise destroyed. Upon the disappearance of the first fluorescence the rarefaction increases slowly, this being a necessary result of particles being projected from the electrode and fastening themselves upon the wall. These particles absorb a large portion of the residual gas. The latter can be again freed by the application of heat to the bulb or otherwise. So much of the effects observed by these investigators. In the instance observed by myself, there must be actual expulsion of matter, and for this speak following facts: (a) the exhaustion is quicker when [illegible] ing shadows while varying the intensity of the radiations, but maintaining all other conditions as nearly as possible alike, it is found that the employment of more intense radiations secures little, if any, advantage, as regards the definition of the details. At first it was thought that all there was needed was to [illegible] very powerful rays. But [illegible] ence was disappoint[illegible] succeeded in [illegible] of impressing a pl[illegible] certainly [illegible] obtained [illegible] There was [illegible] such intense rays [illegible] the plate could be [illegible] from the screen, [illegible] of the shadow was [illegible] observe nothing [illegible] gained. The [illegible] would be at [illegible] as to allow [illegible] plainly, but the [illegible] distinct for all [illegible] a very strong [illegible] impression [illegible] a fact which I [illegible] served and to [illegible] importance in this connection [illegible] following: When taking [illegible] at a small distance [illegible] very intense rays, [illegible] a scarcely perceptible [illegible] Thus, for instance, the [illegible] bones of the hand appear [illegible] transparent. Increasing gradually the distance, [illegible] that the bones cast a sh[illegible] the flesh leaves no impression. [illegible] distance still increased, the [illegible] of the flesh appears, while that [illegible] bones grows deeper, and in this neighborhood a place can be found at which the definition of the shadow is clearest. If the distance is still further continually increased, the detail is lost, and finally only a vague shadow is perceptible, showing [illegible] the outlines of the hand.

This often-noted fact disagrees entirely with any theory of transverse vibrations, but can be easily explained on the assumption of material streams. When the hand is near and the velocity of the stream of particles very great, both bone and flesh are easily

many uses for which induction coils are suitable, they afford ideal instruments. New applications will no doubt be found, but it is very probable that their chief employment will be for purposes of lighting by high-frequency currents, in which Tesla is the recognized pioneer.

We quote the exact language of the inventor in describing a few forms of his appliances for high-frequency phenomena:

The object of my present improvements is to provide a simple, compact and effective apparatus for producing these effects, but adapted more particularly for direct application to and use with existing circuits carrying direct currents, such as the ordinary municipal incandescent lighting circuits. The way in which I accomplish this, so as to meet the requirements of practical and economical operation under the conditions present, will be understood from a general description of the apparatus which I have devised. In any given circuit, which for present purposes may be considered as conveying direct currents or those of substantially the character of direct or continuous currents, and which, for general purposes of illustration, may be assumed to be a branch or derived circuit across the mains from any ordinary source, I interpose a device, or devices, in the nature of a choking coil, in order to give to the circuit a high self-induction. I also provide a circuit controller of any proper character that may be operated to make and break said circuit. Around the break, or point of interruption, I place a condenser, or condensers, to store the energy of the discharge current, and in a local circuit, and in series with such condenser, I place the primary of a transformer, the secondary of which then becomes the source of the currents of high frequency. It will be apparent from a consideration of the conditions involved that, were the condenser to be directly charged by the current from the source, and then discharged this latter relation may be varied at will to regulate the periods of charging and discharging.

The controller C is designed to be rotated by any proper device, such, for example, as an electro-magnetic motor, as shown in Fig. 2, receiving current either from the main source or elsewhere. Around the controller C, or, in general, in parallel therewith, is a condenser H, and in series with the latter the primary K of a transformer, the secondary L of which constitutes the source of the currents of high frequency which may be applied to many useful purposes, as for electric illumination, the operation of Crookes tubes, or the production of high vacua.

L′ indicates the circuit from the secondary, which may be regarded as the working circuit.

A more convenient and simplified arrangement of the apparatus is shown in Fig. 2. In this case the small motor G, which drives the controller, has its field coils in derivation to the main circuit, and the controller C and condenser H are in parallel in the field circuit between the two coils. In such case the field coils M take the place of the choking coils B. In this arrangement, and, in fact, generally, it is preferable to use two condensers, or a condenser in two parts, and to arrange the primary coil of the transformer between them. The interruptions of the field circuit of the motor should be so rapid as to permit only a partial demagnetization of the cores. These latter, however, should in this specific arrangement be laminated.

In a modified arrangement the coils operating the interrupter are placed in series with a coil of large self-induction, or the latter is dispensed with by giving to the coils a suitable self-induction. Quoting the inventor, "this apparatus may be constructed and combined in very compact form and small compass. Its operation involves but a small expenditure of energy, while it requires practically no care or attention for the continued

TESLA'S ELECTRICAL OSCILLATORS.

The important researches and experiments which Nikola Tesla has been carrying on for years, and which have created such a widespread interest in the scientific world, have culminated in the production of thoroughly practical and efficient electrical oscillators or transformers for the conversion of ordinary direct or alternating currents into electrical vibrations of any desired frequency. In five patents, granted to him September 22, 1896, he shows typical forms of his apparatus as adapted to any of the usual sources of supply. The remarkably clear and simple description of the features involved makes it perfectly easy for any one to understand the operation of these most valuable appliances.

The numerous uses to which these high-frequency transformers can be put will, we believe, cause their rapid and extensive introduction, and it is difficult to estimate the benefit which will result to science and industry from their applications. For lighting with phosphorescent bulbs or tubes, for the production of Roentgen phenomena, for the manufacture of ozone, argon and such bodies, for electro-therapeutic employment, and many uses for which induction coils are suitable, they afford ideal instruments. New applications will no doubt be found, but it is very probable that their chief employment will be for purposes of lighting by high-frequency currents, in which Tesla is the recognized pioneer.

We quote the exact language of the patentee in describing a few forms of

into the working circuit, a very large capacity would ordinarily be required, but by the above arrangement the current of high electro-motive force, which is induced at each break of the main circuit, furnishes the proper current for charging the condenser, which may, therefore, be small and inexpensive. Moreover, it will be observed that, since the self-induction of the circuit through which the condenser discharges, as well as the capacity of the condenser itself, may be given practically any desired value, the frequency of the discharge current may be adjusted at will.

Fig. 1 is a diagrammatic illustration of the apparatus, and Fig. 2 a modification of the same.

Referring to Fig. 1, A designates any source of direct current. In any branch of the circuit from said source, such, for example, as would be formed by the conductors A″ A″ from the mains A′ and the conductors K K, are placed self-induction or choking coils B B and a circuit controller C. This latter may be an ordinary metallic disk or cylinder with teeth or separated segments D D, E E, of which one or more pairs, as E E, diametrically opposite, are integral or in electrical contact with the body of the cylinder, so that when the controller is in the position in which the two brushes F F bear upon two of said segments E E, the circuit through the choking coils B will be closed. The segments D D are insulated, and while shown in the drawings as of substantially the same length of arc as the segments E E, this latter relation may be varied at will to regulate the periods of charging and discharging.

The controller C is designed to be rotated by any proper device, such, for example, as an electro-magnetic motor, as shown in Fig. 2, receiving current either from the main source or elsewhere. Around the controller C, or, in general, in parallel therewith, is a condenser H, and in series with the latter the primary K of a transformer,

production of ozone in unlimited amount."

Dwelling specifically upon the conversion of alternating or undulating currents, Mr. Tesla says:

When the potential of the source periodically rises and falls, whether with reversals or not is immaterial, it is essential to economical operation that the intervals of interruption of the charging current should bear a definite time relation to the period of the current, in order that the effective potential of the impulses charging the condenser may be as high as possible. I therefore provide, in case an alternating or equivalent electro-motive force be employed as the source of supply, a circuit controller which will interrupt the charging circuit at instants predetermined with reference to the variations of potential therein. The most practicable means for accomplishing this, of which I am aware, is to employ a synchronous motor connected with the source of supply and operating a circuit controller which interrupts the charging current at or about the instant of highest potential of each wave, and permits the condenser to discharge the energy stored in it through its appropriate circuit. This apparatus, which may be considered as typical of the means employed for carrying out the invention, I have illustrated in the accompanying drawings.

Referring to Fig. 3, A designates any source of alternating or equivalent current, from which lead off mains A' A'. At any point where it is desired to produce the high-frequency currents, a branch circuit B is taken off from the mains, and, in order to raise the potential of the current, a transformer is employed, represented by the primary C and secondary D. The circuit of the secondary includes the energizing coils of a synchronous motor E and a circuit controller, which, in the present instance, in Fig. 3, is shown as composed of a metal disk F with insulated segments F' in its periphery circuit of low self-induction, one terminal of which is connected directly to a condenser terminal and the other to the brush H opposite to that connected with the other condenser terminal, so that the discharge circuit of the condenser will be completed simultaneously with the motor circuit and interrupted while the motor circuit is broken and the condenser being charged.

The discharge circuit contains a primary M of a few turns, and this induces in a secondary N impulses of high potential, which, by reason of their great frequency, are available for the operation of vacuum tubes P, single terminal lamps R, and other novel and useful purposes.

It is obvious that the supply current need not be alternating, provided it be converted or transformed into

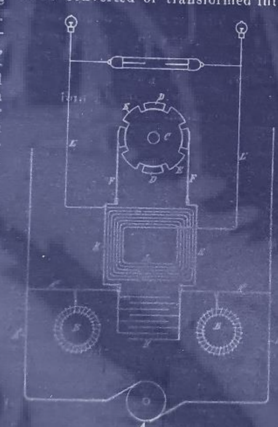

FIG. 1.—TESLA'S ELECTRICAL OSCILLATOR—DIAGRAM ILLUSTRATING CONNECTIONS OF OSCILLATOR AS ADAPTED TO AN ORDINARY MUNICIPAL LIGHTING CIRCUIT.

an alternating current before reach-

With such arrangement it is evident that any two adjacent segments c c become the terminals of an alternating current source, so that if two brushes H H be applied to the periphery of the cylinder, they will take off current during such portion of the wave as the width of segment and position of the brushes may determine. By adjusting the position of the brushes relatively to the cylinder, therefore, the alternating current delivered to the segments c c may be interrupted at any point in its waves.

While the brushes H H are on the conducting segments, the current which they collect stores energy in a circuit of high self-induction formed

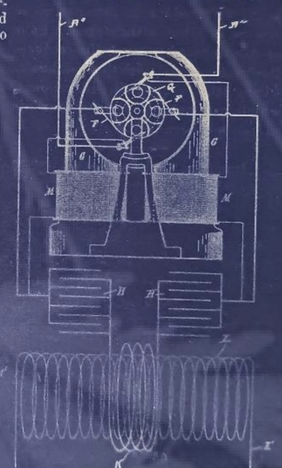

FIG. 2.—TESLA'S ELECTRICAL OSCILLATOR—DRAWING ILLUSTRATING A SIMPLIFIED FORM OF OSCILLATOR AND CONNECTIONS.

by the wires f f, self-induction coils S S, the conductors B B, the brushes and commutator. When this circuit

does not exceed cert[...] limits, has a period of vi[...] its own analogous to th[...] of vibration of a weighted [...] In order to alternately [...] a given circuit of this charac[...] periodic impulses impressed u[...] and to discharge it most effec[...] the frequency of the impresse[...] pulses should bear a definite re[...] to the frequency of vibration [...] sessed by the circuit itself. [...] over, for like reasons the peri[...] vibration of the discharge c[...] should bear a similar relation t[...] impressed impulses or the peri[...] the charging circuit. When the [...] ditions are such that the gener[...] of harmonic vibrations is followe[...] circuits are said to be in reson[...] or in electro-magnetic synchron[...] and this condition I have fo[...] in my system to be highly ad[...] tageous. Hence in practice I ad[...] the electrical constants of the [...] cuits so that in normal operat[...] this condition of resonance [...] approximately attained. To acco[...] plish this, the number of impulses [...] current directed into the chargi[...] circuit per unit time is made equal [...] the period of the charging circu[...] itself, or, generally, to a harmon[...] thereof, and the same relations a[...] maintained between the charging a[...] discharge circuit. Any departur[...] from this condition will result in [...] decreased output, and this fact I tak[...] advantage of in regulating such out[...] put by varying the frequencies o[...] the impulses or vibrations in th[...] several circuits.

Inasmuch as the period of any give[...] circuit depends upon the relations [...] its resistance, self-induction, a[...] capacity, a variation of any [...] or more of these may resul[...] a variation in its period. T[...] are, therefore, various way[...] which the frequencies of [...] tion of the several circuits [...] the system referred to may be [...] but the most practicable and [...]

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It is obvious that the supply current need not be alternating, provided it be converted or transformed into

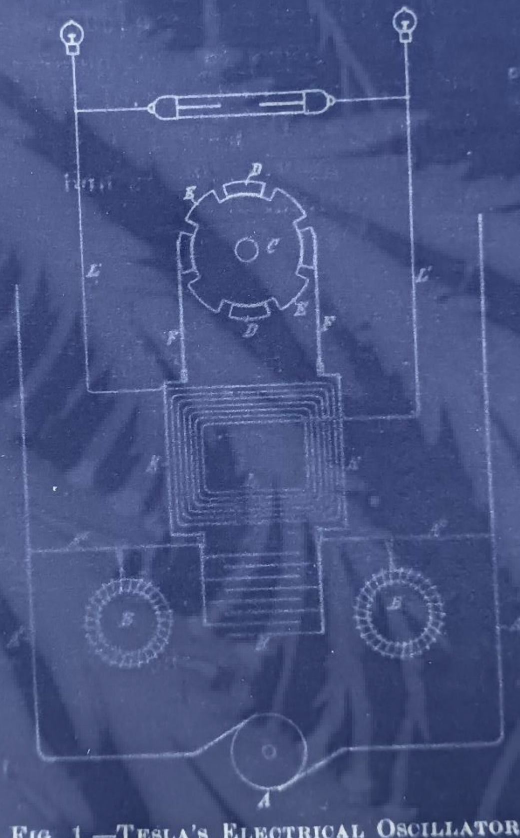

FIG. 1.—TESLA'S ELECTRICAL OSCILLATOR—DIAGRAM ILLUSTRATING CONNECTIONS OF OSCILLATOR AS ADAPTED TO AN ORDINARY MUNICIPAL LIGHTING CIRCUIT.

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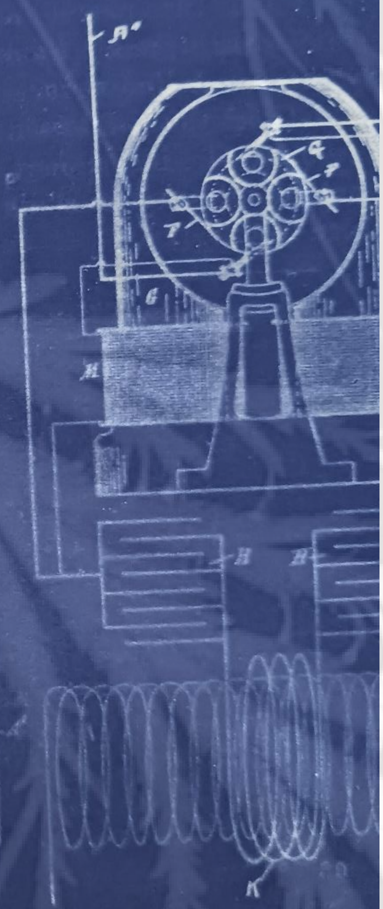

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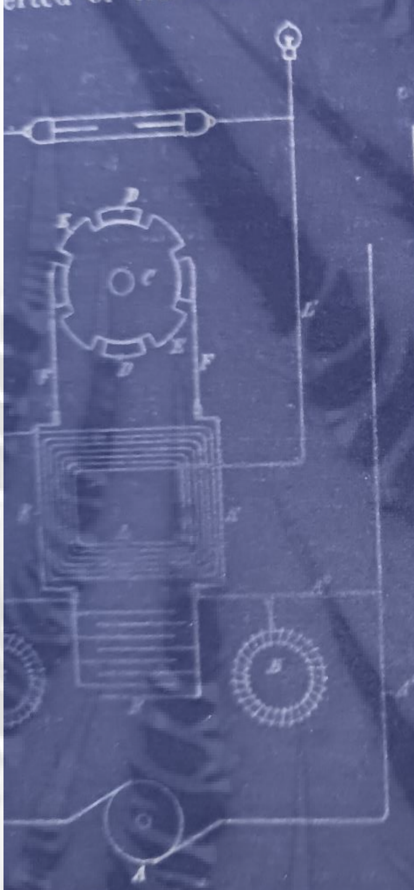

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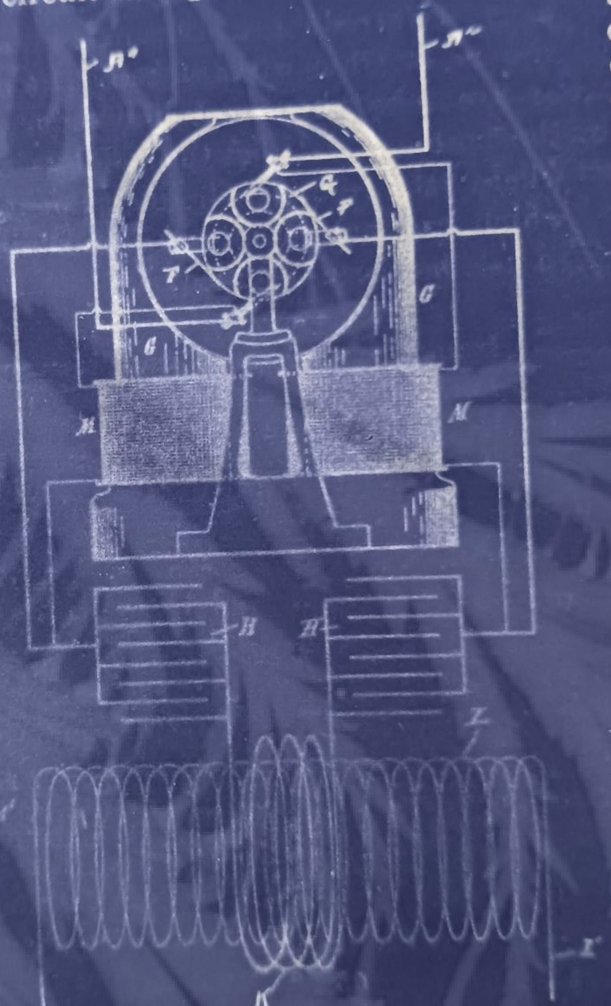

FIG. 2.—TESLA'S ELECTRICAL OSCILLATOR—DRAWING ILLUSTRATING A SIMPLIFIED FORM OF OSCILLATOR AND CONNECTIONS.

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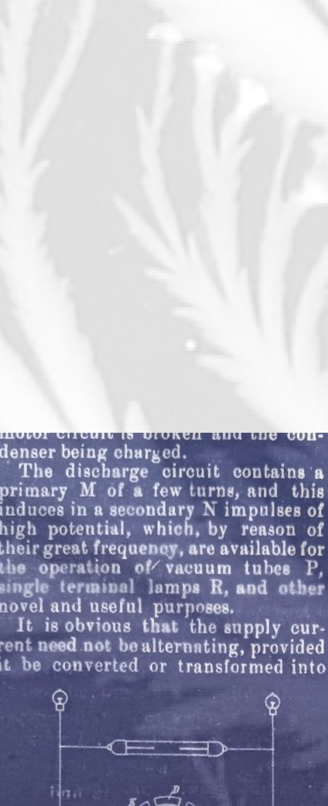

Fig. 1.—Tesla's Electrical Oscillator—Diagram Illustrating Connections of Oscillator as Adapted to an Ordinary Municipal Lighting Circuit.

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determine. By adjusting the position of the brushes relatively to the cylinder, therefore, the alternating current delivered to the segments c c may be interrupted at any point in its waves.

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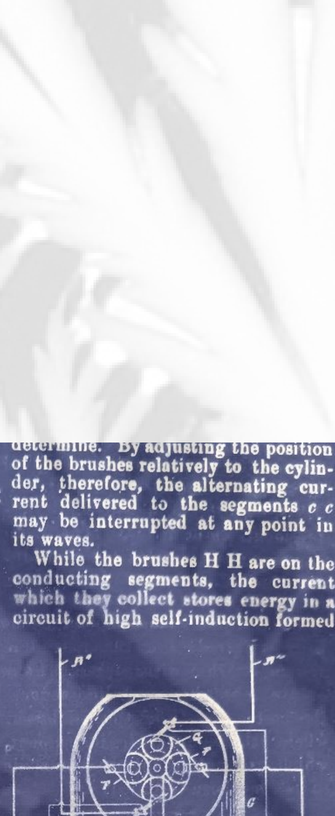

Fig. 2.—Tesla's Electrical Oscillator—Drawing Illustrating a Simplified Form of Oscillator and Connections.

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The condenser discharges into a

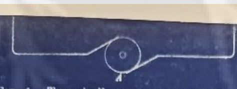

Fig. 1.—Tesla's Electrical Oscillator—Diagram Illustrating Connections of Oscillator as Adapted to an Ordinary Municipal Lighting Circuit.

an alternating current before reaching the controller. For example, the present improvements are applicable to various forms of rotary transformers, as is illustrated in Fig. 4.

E' designates a continuous-current

Fig. 2.—Tesla's Electrical Oscillator—Drawing Illustrating a Simplified Form of Oscillator and Connections.

by the wires $f\,f$, self-induction coils S S, the conductors B B, the brushes and commutator. When this circuit is interrupted by the brushes H H passing on to the insulating segments of the controller, the high-potential discharge of this circuit charges the condensers K K, which then dis-

circuit depends upon its resistance, self-induction capacity, a variation of one or more of these may result a variation in its period. There are, therefore, various ways which the frequencies of vibration of the several circuits the system referred to may be varied but the most practicable and efficient ways of accomplishing the desired result are the following: (*a*) Varying the rate of the impressed impulses of current, or those which are directed from the source of supply into

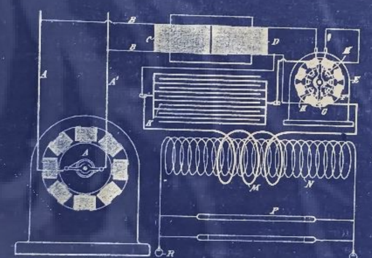

Fig. 3.—Tesla's Electrical Oscillator—Diagram Illustrating Apparatus and Connections as Adapted to a Municipal Alternating Current of Supply.

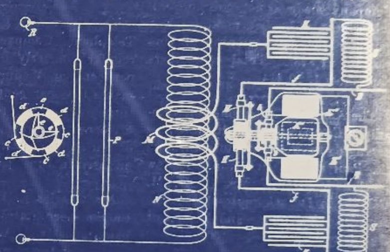

Fig. 4.—Tesla's Electrical Oscillator—Diagram Illustrating Apparatus and Connections as Adapted to a Form of Rotating Transformer Operated from a Municipal Lighting Circuit.

motor, here represented as having four field poles wound with coils E' in shunt to the armature. The line wires B B connect with the brushes $b\,b$ bearing on the usual commutator.

On an extension of the motor shaft is a circuit controller composed of a cylinder, the surface of which is divided into four conducting segments c and four insulating segments d, the former being diametrically connected in pairs, as shown in detail in Fig. 4.

Through the shaft run two insulated conductors $e\ e$ from any two commutator segments 90 degrees apart, and these connect with the two pairs of segments c, respectively.

charge through the circuit of low self-induction containing the primary M. The secondary circuit N contains any devices, as P R, for utilizing the current.

In other arrangements, circuit controllers of special construction are shown mounted on the shaft of a generator, and a transformer is employed in connection to raise the tension of the supply current.

In regard to the regulation of his system Tesla says:

It is well known that every electric circuit, provided its ohmic resistance

the charging circuit, as by varying the speed of the commutator or other circuit controller; (*b*) varying the self-induction of the charging circuit; (*c*) varying the self-induction or capacity of the discharge circuit.

To regulate the output of a single circuit which has no vibration of its own by merely varying its period would evidently require, for any extended range of regulation, a very wide range of variation of period; but in the system described, a very wide range of regulation of the output may be obtained by a very slight change of the frequency of one of the circuits when the above-mentioned rules are observed.

an alternating current before reaching the controller. For example, the present improvements are applicable to various forms of rotary transformers, as is illustrated in Fig. 4.

E' designates a continuous-current motor, here represented as having four field poles wound with coils E' in shunt to the armature. The line wires B B connect with the brushes *b b* bearing on the usual commutator.

On an extension of the motor shaft is a circuit controller composed of a cylinder, the surface of which is divided into four conducting segments *c* and four insulating segments *d*, the former being diametrically connected in pairs, as shown in detail

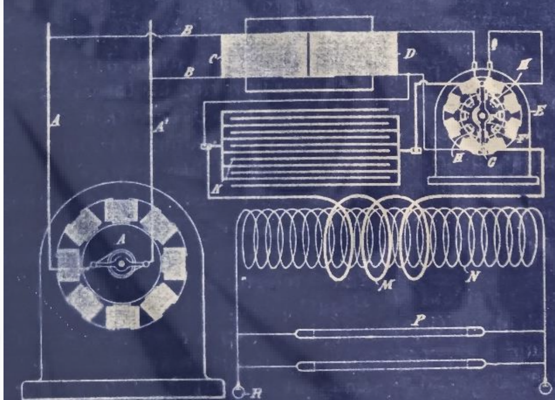

Fig. 3.—Tesla's Electrical Oscillator—Diagram Illustrating Apparatus and Connections as Adapted to a Municipal Alternating Current of Supply.

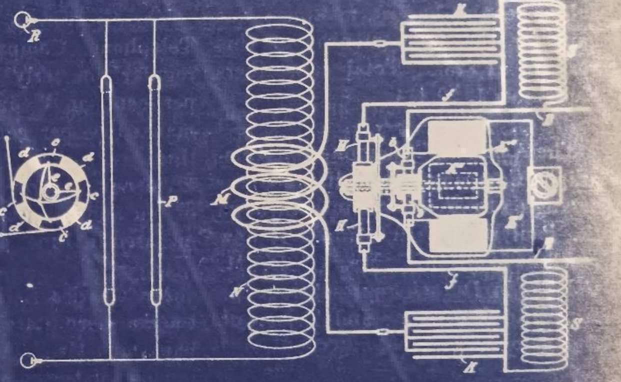

Fig. 4.—Tesla's Electrical Oscillator—Diagram Illustrating Apparatus and Connections as Adapted to a Form of Rotating Transformer Operated from a Municipal Lighting Circuit.

S S, the conductors B B, the brushes and commutator. When this circuit is interrupted by the brushes H H passing on to the insulating segments of the controller, the high-potential discharge of this circuit charges the condensers K K, which then discharge through the circuit of low self-induction containing the primary M. The secondary circuit N contains any devices, as P R, for utilizing the current.

In other arrangements, circuit controllers of special construction are shown mounted on the shaft of a generator, and a transformer is employed in connection to raise the ten-

the system referred to may be vari- but the most practicable and effici- ways of accomplishing the desir- result are the following: (*a*) Vary- ing the rate of the impressed impul- of current, or those which are di- rected from the source of supply in the charging circuit, as by varying the speed of the commutator or other circuit controller; (*b*) varying the self-induction of the charging circuit; (*c*) varying the self-induction or capacity of the discharge circuit.

To regulate the output of a single circuit which has no vibration of its own by merely varying its period would evidently require, for any extended range of regulation, a very wide range of variation of period;

TESLA ON ELECTRICITY.

HIS ADDRESS IN FULL ON THE OCCASION OF THE COMMEMORATION OF THE INTRODUCTION OF NIAGARA FALLS POWER IN BUFFALO AT THE ELLICOTT CLUB, JANUARY 12, 1897.

I have scarcely had courage enough to address an audience on a few unavoidable occasions, and the experience of this evening, even as disconnected from the cause of our meeting, is quite novel to me. Although in those few instances, of which I have retained agreeable memory, my words have met with a generous reception, I never deceived myself, and knew quite well that my success was not due to any excellency in the rhetorical or demonstrative art. Nevertheless, my sense of duty to respond to the request with which I was honored a few days ago was strong enough to overcome my very grave apprehensions in regard to my ability of doing justice to the topic assigned to me. It is true, at times—even now, as I speak—my mind feels full of the subject, but I know that, as soon as I shall attempt expression, the fugitive conceptions will vanish, and I shall experience certain well known sensations of abandonment, chill and silence. I can see already your disappointed countenances and can read in them the painful regret of the mistake in your choice.

These remarks, gentlemen, are not made with the selfish desire of winning your kindness and indulgence on my shortcomings, but with the honest intention of offering you an apology for your disappointment. Nor are they made—as you might be disposed to think—in that playful spirit which, to the enjoyment of the listeners, is often displayed by belated speakers. On the contrary, I am deeply earnest in my wish that I were capable of having the fire of eloquence kindled in me, that I might dwell in adequate terms on this fascinating science of electricity, on the marvelous development which electrical annals have recorded and which, as one of the speakers justly remarked, stamp this age as the Electrical Age, and particularly on the great event we are commemorating this day. Unfortunately, this my desire must remain unfulfilled, but I am hopeful that in my formless and incomplete statements, among the few ideas and facts I shall mention there may be something of interest and usefulness, something befitting this unique occasion.

ance with the fundamental law of motion, which commands acceleration and increase of momentum or accumulation of energy under the action of a continuously acting force and tendency, and is the more true as every advance weakens the elements tending to produce friction and retardation. For, after all, what *is* progress, or—more correctly—development, or evolution, if not a movement, infinitely complex and often unscrutinizable, it is true, but nevertheless exactly determined in quantity as well as in quality of motion by the physical conditions and laws governing? This feature of more recent development is best shown in the rapid merging together of the various arts and sciences by the obliteration of the hard and fast lines of separation, of borders, some of which only a few years ago seemed unsurpassable, and which, like veritable Chinese walls, surrounded every department of inquiry and barred progress. A sense of connectedness of the various apparently widely different forces and phenomena we observe is taking possession of our minds, a sense of deeper understanding of nature as a whole, which, though not yet quite clear and defined, is keen enough to inspire us with the confidence of vast realizations in the near future.

But these features chiefly interest the scientific man, the thinker and reasoner. There is another feature which affords us still more satisfaction and enjoyment, and which is of still more universal interest, chiefly because of its bearing upon the welfare of mankind. Gentlemen, there is an influence which is getting strong and stronger day by day, which shows itself more and more in all departments of human activity, an influence most fruitful and beneficial—the influence of the artist. It was a happy day for the mass of humanity when the artist felt the desire of becoming a physician, an electrician, an engineer or mechanician or—whatnot—a mathematician or a financier; for it was he who wrought all these wonders and grandeur we are witnessing. It was he who abolished that small, pedantic, narrow-grooved school teaching which made of an aspiring student a galley-slave, and he who allowed freedom in the choice of subject of study according to one's pleasure and inclination, and so facilitated development.

Some, who delight in the exercise of the powers of criticism, call this an assymetrical development, a degeneration or departure from the normal, or even a degradation of the race. But they are mistaken. This is a welcome state of things, a blessing, a wise subdivision of labors, the establishment of conditions most favorable to progress. Let one concentrate all his energies in one single great effort, let him perceive a single truth, even though he be consumed by the sacred fire, then millions of less gifted men can easily follow. Therefore it is not as much quantity as quality of work

they are going to pounce upon each other at a given signal and destroy themselves; that they are all trying to outdo that victorious, great, wonderful German army, against which there is no resistance, for every German has the discipline in his very blood—every German is a soldier. But these men are in error. Look only at our recent experience with the British in that Venezuela difficulty. Two other nations might have crashed together, but not the Anglo-Saxons; they are too far ahead. The men who tell you this are ignoring forces which are continually at work, silently but resistlessly—forces which say Peace!

There is the genuine artist, who inspires us with higher and nobler sentiments, and makes us abhor strife and carnage. There is the engineer, who bridges gulfs and chasms, and facilitates contact and equalization of the heterogeneous masses of humanity. There is the mechanic, who comes with his beautiful time and energy-saving appliances, who perfects his flying machine, not to drop a bag of dynamite on a city or vessel, but to facilitate transport and travel. There, again, is the chemist, who opens new resources and makes existence more pleasant and secure; and there is the electrician, who sends his messages of peace to all parts of the globe. The time will not be long in coming when those men who are turning their ingenuity to inventing quick-firing guns, torpedoes and other implements of destruction—all the while assuring you that it is for the love and good of humanity—will find no takers for their odious tools, and will realize that, had they used their inventive talent in other directions, they might have reaped a far better reward than the sestertia received. And then, and none too soon, the cry will be echoed everywhere. Brethren, stop these highhanded methods of the strong, these remnants of barbarism so inimical to progress! Give that valiant warrior opportunities for displaying a more commendable courage than that he shows when, intoxicated with victory, he rushes to the destruction of his fellow-men. Let him toil day and night with a small chance of achieving and yet be unflinching; let him challenge the dangers of exploring the heights of the air and the depths of the sea; let him brave the dread of the plague, the heat of the tropic desert and the ice of the polar region. Turn your energies to warding off the common enemies and dangers, the perils that are all around you, that threaten you in the air you breathe, in the water you drink, in the food you consume. Is it not strange, is it not shame, that we, beings in the highest state of development in this our world, beings with such immense powers of thought and action, we, the masters of the globe, should be absolutely at the mercy of our unseen foes, that we should not know whether a swallow of food or drink brings joy and life or pain and destruction to us! In this most modern and sensible warfare, in which the bacteriologist leads, the services

broad one of converting the greatest possible amount of heat energy into mechanical power, but it was rather the specific problem of obtaining the mechanical power in such form as to be best suitable for general use. As the reciprocating motion of the piston was not convenient for practical purposes, except in very few instances, the piston was connected to a crank, and thus rotating motion was obtained, which was more suitable and preferable, though it involved numerous disadvantages incident to the crude and wasteful means employed. But until quite recently there were at the disposal of the engineer, for the transformation and transmission of the motion of the piston, no better means than rigid mechanical connections. The past few years have brought forcibly to the attention of the builder the electric motor, with its ideal features. Here was a mode of transmitting mechanical motion simpler by far, and also much more economical. Had this mode been perfected earlier, there can be no doubt that, of the many different types of engine, the majority would not exist, for just as soon as an engine was coupled with an electric generator a type was produced capable of almost universal use. From this moment on there was no necessity to endeavor to perfect engines of special designs capable of doing special kinds of work. The engineer's task became now to concentrate all his efforts upon one type, to perfect one kind of engine—the best, the universal, the engine of the immediate future; namely, the one which is best suitable for the generation of electricity. The first efforts in this direction gave a strong impetus to the development of the reciprocating high-speed engine, and also to the turbine, which latter was a type of engine of very limited practical usefulness, but became, to a certain extent, valuable in connection with the electric generator and motor. Still, even the former engine, though improved in many particulars, is not radically changed, and even now has the same objectionable features and limitations. To do away with these as much as possible, a new type of engine is being perfected in which more favorable conditions for economy are maintained, which expands the working fluid with utmost rapidity and loses little heat on the walls, an engine stripped of all usual regulating mechanism—packings, oilers and other appendages—and forming part of an electric generator; and in this type, I may say, I have implicit faith.

The gas or explosive engine has been likewise profoundly affected by the commercial introduction of electric light and power, particularly in quite recent years. The engineer is turning his energies more and more in this direction, being attracted by the prospect of obtaining a higher thermodynamic efficiency. Much larger engines are now being built, the construction is constantly improved, and a novel type of engine, best suitable for the generation of

Weekly, if not daily, we learn through the journals of a new advance into some unexplored region, where at every step success beckons friendly, and leads the toiler on to hard and harder tasks.

But among all these many departments of research, these many branches of industry, new and old, which are being rapidly expanded, there is one dominating all others in importance—one which is of the greatest significance for the comfort and welfare, not to say for the existence, of mankind, and that is the electrical transmission of power. And in this most important of all fields, gentlemen, long afterwards, when time will have placed the events in their proper perspective, and assigned men to their deserved places, the great event we are commemorating to-day will stand out as designating a new and glorious epoch in the history of humanity—an epoch grander than that marked by the advent of the steam engine. We have many a monument of past ages; we have the palaces and pyramids, the temples of the Greek and the cathedrals of Christendom. In them is exemplified the power of men, the greatness of nations, the love of art and religious devotion. But that monument at Niagara has something of its own, more in accord with our present thoughts and tendencies. It is a monument worthy of our scientific age, a true monument of enlightenment and of peace. It signifies the subjugation of natural forces to the service of man, the discontinuance of barbarous methods, the relieving of millions from want and suffering. No matter what we attempt to do, no matter to what fields we turn our efforts, we are dependent on power. Our economists may propose more economical systems of administration and utilization of resources, our legislators may make wiser laws and treaties, it matters little; that kind of help can be only temporary. If we want to reduce poverty and misery, if we want to give to every deserving individual what is needed for a safe existence of an intelligent being, we want to provide more machinery, more power. Power is our mainstay, the primary source of our many-sided energies. With sufficient power at our disposal we can satisfy most of our wants and offer a guaranty for safe and comfortable existence to all, except perhaps to those who are the greatest criminals of all—the voluntarily idle.

The development and wealth of a city, the success of a nation, the progress of the whole human race, is regulated by the power available. Think of the victorious march of the British, the like of which history has never recorded. Apart from the qualities of the race, which have been of great moment, they own the conquest of the world to—coal. For with coal they produce their iron; coal furnishes them light and heat; coal drives the wheels of their immense manufacturing establishments, and coal propels their conquering fleets. But the stores are being more and more exhausted, the labor is getting dearer and dearer, and the demand is continuously increasing. It must be clear to every one that soon some new source of power supply must be opened up, or that at least the present methods must be materially improved. A great deal is expected from a more economical utilization of the stored energy of the carbon in a battery; but while the attainment of such a result would be hailed as a great achievement, it would not be as much of an advance towards the ultimate and permanent method of obtaining power as some engineers seem to believe. By reasons both of economy and convenience, of course, place the batteries at or near the coal mine, and from there transmit the energy to distant points in the form of high-tension alternating currents obtained from rotating transformers, but even in this most favorable case the process would be a barbarous one, certainly more so than the present, as it would still involve the consumption of material, while at the same time it would restrict the engineer and mechanic in the exercise of their beautiful art. As to the energy supply in small isolated places as dwellings, I have placed my confidence in the development of a light storage battery, involving the use of chemicals manufactured by cheap water power, such as some carbide or oxygen-hydrogen cell.

But we shall not satisfy ourselves simply with improving steam and explosive engines or inventing new batteries; we have something much better to work for, a greater task to fulfill. We have to evolve means for obtaining energy from stores which are forever inexhaustible, to perfect methods which do not imply consumption and waste of any material whatever. Upon this great possibility, which I have long ago recognized, upon this great problem, the practical solution of which means so much for humanity, I have myself concentrated my efforts since a number of years, and a few happy ideas which came to me have inspired me to attempt the most difficult, and given me strength and courage in adversity. Nearly six years ago my confidence had become strong enough to prompt me to an expression of hope in the ultimate solution of this all-dominating problem. I have made progress since, and have passed the stage of mere conviction such as is derived from a diligent study of known facts, conclusions and calculations. I now feel sure that the realization of that idea is not far off. But precisely for this reason I feel impelled to point out here an important fact, which I hope will be remembered. Having examined for a long time the possibilities of the development I refer to, namely, that of the operation of engines on any point of the earth by the energy of the medium, I find that even under the theoretically best conditions such a method of obtaining power can not equal in economy, simplicity and many other features the present method, involving a conversion of the mechanical energy of running water into electrical energy and the transmission of the latter in the form of currents of very high tension to great distances. Provided, therefore, that we can avail ourselves of currents of sufficiently high tension, a waterfall affords us the most advantageous means of getting power from the sun sufficient for all our wants, and this recognition has impressed me strongly with the future importance of the water power, not so much because of its commercial value, though it may be very great, but chiefly because of its bearing upon our safety and welfare. I am glad to say that also in this latter direction my efforts have not been unsuccessful, for I have devised means which will allow us the use in power transmission of electro-motive forces much higher than those practicable with ordinary apparatus. In fact, progress in this field has given me fresh hope that I shall see the fulfillment of one of my fondest dreams; namely, the transmission of power from station to station without the employment of any connecting wire. Still, whatever method of transmission be ultimately adopted, nearness to the source of power will remain an important advantage.

Gentlemen, some of the ideas I have expressed may appear to many of you hardly realizable; nevertheless, they are the result of long-continued thought and work. You is to be congratulated. With resources unequaled, with commercial facilities and advantages such as few cities in the world possess, and with the enthusiasm and progressive spirit of its citizens, it is sure to become one of the greatest industrial centers of the globe.

Editors Enjoy a Trolley Ride.

The Republican Editorial Association, of the State of New York, held its annual meeting in this city last week. They devoted the afternoon of Thursday to a trolley ride over Brooklyn in the beautiful parlor trolley cars which President Rossiter, of the Brooklyn Street Railway Company, provided for the occasion. Lunch was served in the cars and it was a very enjoyable as well as novel experience for the visiting editors to be whirled through the city of Brooklyn and suburbs while enjoying an excellent repast. After the ride they visited the Brooklyn Navy Yard, and were later entertained at a banquet at the Union League Club, of Brooklyn, through the courtesy of the president of the association, Hon. William Berri, proprietor of the Brooklyn *Standard Union*. The after-dinner speeches at the banquet were of unusual interest and were made by the following eminent gentlemen: Chauncey M. Depew, Elihu Root, Paul Dana, W. J. Arkell, George H. Daniels, Joseph Howard, Jr., Henry Watterson and Lieut. R. E. Peary, U. S. N.

Another Reason Why the Cable Should Go.

[*From the New York Evening Sun.*]

If you stand on a corner and wave your umbrella at a cable car, and it whirls past you without slowing down, don't blame the gripman until you have looked in the newspapers to see how many were injured. It was probably a runaway. The man in front may have been doing his best.

A Belt Manufacturer Assigns.

The assignment is reported of Edwin A. Burgess, a belt manufacturer in Providence, R. I., who did business under the name of A. Burgess & Son.

members, is often displayed by belated speakers. On the contrary, I am deeply earnest in my wish that I were capable of having the fire of eloquence kindled in me, that I might dwell in adequate terms on this fascinating science of electricity, on the marvelous development which electrical annals have recorded and which, as one of the speakers justly remarked, stamp this age as the Electrical Age, and particularly on the great event we are commemorating this day. Unfortunately, this my desire must remain unfulfilled, but I am hopeful that in my formless and incomplete statements, among the few ideas and facts I shall mention there may be something of interest and usefulness, something befitting this unique occasion.

Gentlemen, there are a number of features clearly discernible in, and characteristic of, human intellectual progress in more recent times—features which afford great comfort to the minds of all those who have really at heart the advancement and welfare of mankind.

First of all, the inquiry, by the aid of the microscope and electrical instruments of precision, into the nature of our organs and senses, and particularly of those through which we commune directly with the outside world and through which knowledge is conveyed to our minds, has revealed their exact construction and mode of action, which is in conformity with simple and well established physical principles and laws. Hence the observations we make and the facts we ascertain by their help are *real* facts and observations, and our knowledge is *true* knowledge. To illustrate: Our knowledge of form, for instance, is dependent upon the positive fact that light propagates in straight lines, and, owing to this, the image formed by a lens is exactly similar to the object seen. Indeed, my thoughts in such fields and directions have led me to the conclusion that most all human knowledge is based on this simple truth, since practically every idea or conception—and therefore all knowledge—presupposes visual impressions. But if light would not propagate in accordance with the law mentioned, but in conformity with any other law which we might presently conceive, whereby not only the image might not bear any likeness to the object seen, but even the images of the same object at different times or distances might not resemble each other, then our knowledge of form would be very defective, for then we might see, for example, a three-cornered figure as a six or twelve-cornered one. With the clear understanding of the mechanism and mode of action of our organs, we remove all doubts as to the *reality* and *truth* of the impressions received from the outside, and thus we bar out—forever, we may hope—that unhealthy speculation and skepticism into which formerly even strong minds were apt to fall.

Let me tell you of another comforting feature. The progress in a measured time is nowadays more rapid and greater than it ever was before. This is quite in accord- student a galley-slave, and he who allowed freedom in the choice of subject of study according to one's pleasure and inclination, and so facilitated development.

Some, who delight in the exercise of the powers of criticism, call this an assymetrical development, a degeneration or departure from the normal, or even a degradation of the race. But they are mistaken. This is a welcome state of things, a blessing, a wise subdivision of labors, the establishment of conditions most favorable to progress. Let one concentrate all his energies in one single great effort, let him perceive a single truth, even though he be consumed by the sacred fire, then millions of less gifted men can easily follow. Therefore it is not as much quantity as quality of work which determines the magnitude of the progress.

It was the artist, too, who awakened that broad philanthropic spirit which, even in old ages, shone in the teachings of noble reformers and philosophers, that spirit which makes men in all departments and positions work not as much for any material benefit or compensation—though reason may command this also—but chiefly for the sake of success, for the pleasure there is in achieving it and for the good they might be able to do thereby to their fellow-men. Through his influence types of men are now pressing forward, impelled by a deep love for their study, men who are doing wonders in their respective branches, whose chief aim and enjoyment is the acquisition and spread of knowledge, men who look far above earthly things, whose banner is Excelsior! Gentlemen, let us honor the artist, let us thank him, let us drink his health!

Now, in all these enjoyable and elevating features which characterize modern intellectual development, electricity, the expansion of the science of electricity, has been a most potent factor. Electrical science has revealed to us the true nature of light, has provided us with innumerable appliances and instruments of precision, and has thereby vastly added to the exactness of our knowledge. Electrical science has disclosed to us the more intimate relation existing between widely different forces and phenomena and has thus led us to a more complete comprehension of Nature and its many manifestations to our senses. Electrical science, too, by its fascination, by its promises of immense realizations, of wonderful possibilities chiefly in humanitarian respects, has attracted the attention and enlisted the energies of the artist; for where is there a field in which his God-given powers would be of greater benefit to his fellow-men than this unexplored, almost virgin, region, where, like in a silent forest, a thousand voices respond to every call?

With these comforting features, with these cheering prospects, we need not look with any feeling of incertitude or apprehension into the future. There are pessimistic men, who, with anxious faces, continuously whisper in your ear that the nations are secretly arming—arming to the teeth; that lenge the dangers of exploring the heights of the air and the depths of the sea; let him brave the dread of the plague, the heat of the tropic desert and the ice of the polar region. Turn your energies to warding off the common enemies and dangers, the perils that are all around you, that threaten you in the air you breathe, in the water you drink, in the food you consume. Is it not strange, is it not shame, that we, beings in the highest state of development in this our world, beings with such immense powers of thought and action, we, the masters of the globe, should be absolutely at the mercy of our unseen foes, that we should not know whether a swallow of food or drink brings joy and life or pain and destruction to us! In this most modern and sensible warfare, in which the bacteriologist leads, the services electricity will render will prove invaluable. The economical production of high-frequency currents, which is now an accomplished fact, enables us to generate easily and in large quantities ozone for the disinfection of the water and the air, while certain novel radiations recently discovered give hope of finding effective remedies against ills of microbic origin, which have heretofore withstood all efforts of the physician. But let me turn to a more pleasant theme.

I have referred to the merging together of the various sciences or departments of research, and to a certain perception of intimate connection between the manifold and apparently different forces and phenomena. Already we know, chiefly through the efforts of a bold pioneer, that light, radiant heat, electrical and magnetic actions are closely related, not to say identical. The chemist professes that the effects of combination and separation of bodies he observes are due to electrical forces, and the physician and physiologist will tell you that even life's progress is electrical. Thus electrical science has gained a universal meaning, and with right this age can claim the name "Age of Electricity."

I wish much to tell you on this occasion—I may say I actually burn for desire of telling you—what electricity really *is*, but I have very strong reasons, which my co-workers will best appreciate, to follow a precedent established by a great and venerable philosopher, and I shall not dwell on this purely scientific aspect of electricity.

There is another reason for the claim which I have before stated which is even more potent than the former, and that is the immense development in all electrical branches in more recent years and its influence upon other departments of science and industry. To illustrate this influence I only need to refer to the steam or gas engine. For more than half a century the steam engine has served the innumerable wants of man. The work it was called to perform was of such variety and the conditions in each case were so different that, of necessity, a great many types of engines have resulted. In the vast majority of cases the problem put before the engineer was not, as it should have been, the conditions for economy are maintained, which expands the working fluid with utmost rapidity and loses little heat on the walls, an engine stripped of all usual regulating mechanism—packings, oilers and other appendages—and forming part of an electric generator; and in this type, I may say, I have implicit faith.

The gas or explosive engine has been likewise profoundly affected by the commercial introduction of electric light and power, particularly in quite recent years. The engineer is turning his energies more and more in this direction, being attracted by the prospect of obtaining a higher thermodynamic efficiency. Much larger engines are now being built, the construction is constantly improved, and a novel type of engine, best suitable for the generation of electricity, is being rapidly evolved.

There are many other lines of manufacture and industry in which the influence of electrical development has been even more powerfully felt. So, for instance, the manufacture of a great variety of articles of metal, and especially of chemical products. The welding of metals by electricity, though involving a wasteful process, has, nevertheless, been accepted as a legitimate art, while the manufacture of metal sheet, seamless tubes and the like affords promise of much improvement. We are coming gradually, but surely, to the fusion of bodies and reduction of all kinds of ores—even of iron ores—by the use of electricity, and in each of these departments great realizations are probable. Again, the economical conversion of ordinary currents of supply into high-frequency currents opens up new possibilities, such as the combination of the atmospheric nitrogen and the production of its compounds; for instance, ammonia and nitric acid, and their salts, by novel processes.

The high-frequency currents also bring us to the realization of a more economical system of lighting; namely, by means of phosphorescent bulbs or tubes, and enable us to produce with these appliances light of practically any candle-power. Following other developments in purely electrical lines, we have all rejoiced in observing the rapid strides made, which, in quite recent years, have been beyond our most sanguine expectations. To enumerate the many advances recorded is a subject for the reviewer, but I can not pass without mentioning the beautiful discoveries of Lenard and Roentgen, particularly the latter, which have found such a powerful response throughout the scientific world that they have made us forget, for a time, the great achievement of Linde in Germany, who has effected the liquefaction of air on an industrial scale by a process of continuous cooling; the discovery of argon by Lord Rayleigh and Professor Ramsay, and the splendid pioneer work of Professor Dewar in the field of low temperature research. The fact that the United States have contributed a very liberal share to this prodigious progress must afford to all of us great satisfaction. While

the workers in other countries and all those who, by profession or inclination, are devoting themselves to strictly scientific pursuits, we have particular reasons to mention with gratitude the names of those who have so much contributed to this marvelous development of electrical industry in this country. Bell, who, by his admirable invention enabling us to transmit speech to great distances, has profoundly affected our commercial and social relations, and even our very mode of life; Edison, who, had he not done anything else beyond his early work in incandescent lighting, would have proved himself one of the greatest benefactors of the age; Westinghouse, the founder of the commercial alternating system; Brush, the great pioneer of arc lighting; Thomson, who gave us the first practical welding machine, and who, with keen sense, contributed very materially to the development of a number of scientific and industrial branches; Weston, who once led the world in dynamo design, and now leads in the construction of electric instruments; Sprague, who, with rare energy, mastered the problem and insured the success of practical electrical railroading; Acheson, Hall, Willson and others, who are creating new and revolutionizing industries here under our very eyes at Niagara. Nor is the work of these gifted men nearly finished at this hour. Much more is still to come, for, fortunately, most of them are still full of enthusiasm and vigor. All of these men and many more are untiringly at work investigating new regions and opening up unsuspected and promising fields. Weekly, if not daily, we learn through the journals of a new advance into some unexplored region, where at every step success beckons friendly, and leads the toiler on to hard and harder tasks.

But among all these many departments of research, these many branches of industry, new and old, which are being rapidly expanded, there is one dominating all others in importance—one which is of the greatest significance for the comfort and welfare, not to say for the existence, of mankind, and that is the electrical transmission of power. And in this most important of all fields, gentlemen, long afterwards, when time will have placed the events in their proper perspective, and assigned men to their deserved places, the great event we are commemorating to-day will stand out as designating a new and glorious epoch in the history of humanity—an epoch grander than that marked by the advent of the steam engine. We have many a monument of past ages; we have the palaces and pyramids, the temples of the Greek and the cathedrals of Christendom. In them is exemplified the power of men, the greatness of nations, the love of art and religious devotion. But that monument at Niagara has something of its own, more in accord with our present thoughts and tendencies. It is a monument worthy of our scientific age, a true monument of enlightenment and of peace. It signifies the subjugation of natural forces to the service of man, the discontinuance of barbarous methods, the relieving of millions from want and suffering. No matter what we attempt to do, no matter to what fields we turn our efforts, we are dependent on power. Our economists may propose more economical systems of administration and utilization of resources, our legislators may make wiser laws and treaties, it matters little; that kind of help can be only temporary. If we want to reduce poverty and misery, if we want to give to every deserving individual what is needed [illegible] safe existence of an intelligent being, [illegible] want to provide more machinery, more power. Power is our mainstay, the primary source of our many-sided energies. With sufficient [illegible]ience we are driven to the general adoption of a system of energy supply from central stations, and for such purposes the beauties of the mechanical generation of electricity can not be exaggerated. The advantages of this universally accepted method are certainly so great that the probability of replacing the engine dynamos by batteries is, in my opinion, a remote one, the more so as the high-pressure steam engine and gas engine give promise of a considerably more economical thermodynamic conversion. Even if we had this day such an economical coal battery, its introduction in central stations would by no means be assured, as its use would entail many inconveniences and drawbacks. Very likely the carbon could not be burned in its natural form as in a boiler, but would have to be specially prepared to secure uniformity in the current generation. There would be a great many cells needed to make up the electro-motive force usually required. The process of cleaning and renewal, the handling of nasty fluids and gases and the great space necessary for so many batteries would make it difficult, if not commercially unprofitable, to operate such a plant in a city or densely populated district. Again, if the station be erected in the outskirts, the conversion by rotating transformers or otherwise would be a serious and unavoidable drawback. Furthermore, the regulating appliances and other accessories which would have to be provided would probably make the plant fully as much, if not more, complicated than the present. We might, of course, place the batteries at or near the coal mine, and from there transmit the energy to distant points in the form of high-tension alternating currents obtained from rotating transformers, but even in this most favorable case the process would be a barbarous one, certainly more so than the present, as it would still involve the consumption of material, while at the same time it would restrict the engineer and mechanic in the exercise of their beautiful art. As to the energy supply in small isolated places as dwellings, I have placed my confidence in the development of a light storage battery, involving the use of chemicals manufactured by cheap water power, such as some carbide or oxygen-hydrogen cell.

But we shall not satisfy ourselves simply with improving steam and explosive engines or inventing new batteries; we have something much better to work for, a greater task to fulfill. We have to evolve means for obtaining energy from stores which are forever inexhaustible, to perfect methods which do not imply consumption and waste of any material whatever. Upon this great possibility, which I have long ago recognized, upon this great problem, the practical solution of which means so much for humanity, I have myself concentrated my efforts since a number of years, and a few happy ideas which came to me have inspired me to attempt the most difficult, and given me strength and courage in adversity. Nearly six years ago my confidence had become strong enough to prompt me to an expression of hope in the ultimate solution of this all-dominating problem. I have made progress since, and have passed the stage of mere conviction such as is derived from a diligent study of known facts, conclusions and calculations. I now feel sure that the realization of that idea is not far off. But precisely for this reason I feel impelled to point out here an important fact, which I hope will be remembered. Having examined for a long time the possibilities of the development I refer to, namely, that of the operation of engines on any point of the earth by the energy of the medium, I find that even under the theoretically best conditions such a method of [illegible] would judge them more justly if you would have devoted your life to them, as I have done. With ideas it is like with dizzy heights you climb: At first they cause you discomfort and you are anxious to get down, distrustful of your own powers; but soon the remoteness of the turmoil of life and the inspiring influence of the altitude calm your blood; your step gets firm and sure and you begin to look—for dizzier heights. I have attempted to speak to you on "Electricity," its development and influence, but I fear that I have done it much like a boy who tries to draw a likeness with a few straight lines. But I have endeavored to bring out one feature, to speak to you in one strain which I felt sure would find response in the hearts of all of you, the only one worthy of this occasion—the humanitarian. In the great enterprise at Niagara we see not only a bold engineering and commercial feat, but far more, a giant stride in the right direction as indicated both by exact science and philanthropy. Its success is a signal for the utilization of water powers all over the world, and its influence upon industrial development is incalculable. We must all rejoice in the great achievement and congratulate the intrepid pioneers who have joined their efforts and means to bring it about. It is a pleasure to learn of the friendly attitude of the citizens of Buffalo and of the encouragement given to the enterprise by the Canadian authorities. We shall hope that other cities, like Rochester on this side and Hamilton and Toronto in Canada, will soon follow Buffalo's lead. This fortunate city herself is to be congratulated. With resources now unequaled, with commercial facilities and advantages such as few cities in the world possess, and with the enthusiasm and progressive spirit of its citizens, it is sure to become one of the greatest industrial centers of the globe.

Editors Enjoy a Trolley Ride.

The Republican Editorial Association, of the State of New York, held its annual meeting in this city last week. They devoted the afternoon of Thursday to a trolley ride over Brooklyn in the beautiful parlor trolley cars which President Rossiter, of the Brooklyn Street Railway Company, provided for the occasion. Lunch was served in the cars and it was a very enjoyable as well as novel experience for the visiting editors to be whirled through the city of Brooklyn and suburbs while enjoying an excellent repast. After the ride they visited the Brooklyn Navy Yard, and were later entertained at a banquet at the Union League Club, of Brooklyn, through the courtesy of the president of the association, Hon. William Berri, proprietor of the Brooklyn *Standard Union*. The after-dinner speeches at the banquet were of unusual interest and were made by the following eminent gentlemen: Chauncey M. Depew, Elihu Root, Paul Dana, W. J. Arkell,

THE NEW YORK ACADEMY OF SCIENCE.

AN INTERESTING ELECTRICAL EXHIBITION — ADDRESS BY NIKOLA TESLA, ANNOUNCING RECENT ACHIEVEMENTS.

The New York Academy of Sciences gave its fourth annual reception and exhibit of recent progress in science in the American Museum of Natural History, New York, April 5 and 6.

In the division devoted to chemistry, in charge of Charles A. Doremus, were exhibited a number of electric furnaces, and in the electrical division, in charge of G. F. Sever, were to be seen a number of historical collections of incandescent and arc lamps, instruments of precision, Crookes tubes, induction coils, etc. Mr. W. H. Meadowcroft exhibited a Thomson 14 inch spark inductorium, and tubes and fluoroscopes, and Dr. M. I. Pupin had on view an induction coil and circuit breaker for the generation of Roentgen rays. Dr. Max Osterberg exhibited some specimens of German tubes, and Dr. Doremus showed one of the original Henry induction coils.

Tuesday evening a large audience assembled to listen to an address by Nikola Tesla on "The Streams of Lenard and Roentgen and Novel Apparatus for their Production". The lecturer had on exhibition a number of his perfected electrical oscillators, designed particularly to be used in place of the induction coils of old type. He exhibited numerous diagrams illustrating results obtained by him in his experiments to ascertain the nature of

Mr. Tesla first described the instruments exhibited, dwelling on the principles underlying them, and he illustrated, in a few striking experiments, the practical and economical features of the machines. The greatest interest seemed to be evinced by the audience when he lighted brilliantly a vacuum tube with one of his machines, giving, as he said, 800,000 vibrations a second. What rendered them particularly valuable, he stated, was that they worked equally well on alternating or direct-current circuits, and transform these currents with high economy into high frequency electrical vibrations.

Mr. Tesla announced two important discoveries relating to the Roentgen rays. First, he said he had discovered a new and powerful source of the rays in an electric arc, formed under peculiar conditions. The second discovery was the deflection of the Roentgen rays by means of a magnet. This discovery is particularly important in establishing the identity of the Roentgen rays, and those discovered by Lenard in 1891, and is, therefore, one of the most valuable contributions to our knowledge of these rays.

Tesla dwelt also on some phenomena of rotation of bodies in bulbs, and, among other things, described his method of determining exactly the speed of a dynamo when taking readings.

To a few interested scientific men Mr. Tesla showed a great number of diagrams illustrating experiments he had performed which tended to prove the correctness of the views he holds in regard to the Roentgen phenomena being caused by material particles projected with great velocity.

The ELECTRICAL REVIEW hopes to be able to present in full, in an early issue, Mr. Tesla's lecture.

The Western Telephone Construction Company Again Victorious — Court Decides Roosevelt

Lenard and Roentgen and Novel Apparatus for their Production". The lecturer had on exhibition a number of his perfected electrical oscillators, designed particularly to be used in place of the induction coils of old type. He exhibited numerous diagrams illustrating results obtained by him in his experiments, to ascertain the nature of the Roentgen rays. There were over 100 different working drawings of bulbs, showing the extent of the ground covered by the lecturer in this field. There were, besides, a number of remarkable photographs exhibited, which were taken by means of one of the small oscillators exhibited. These instruments and photographs were examined with the keenest interest after the lecture by a large number who remained and insisted on a supplementary lecture, which Mr. Tesla kindly consented to give, notwithstanding that, as he playfully remarked, he had not yet had his dinner.

Mr. Tesla introduced the subject of his lecture by stating that at the close of 1894 he investigated the actinic power of phosphorescent bodies, and during these experiments, which were carried on by the assistance of Tonnelé & Company, photographers of this city, working for the *Century Magazine*, a great number of plates showed curious marks and defects, which were noted both by the speaker and the photographers, but not recognized as being due to the Roentgen rays. Just as he was beginning to look into the nature of the phenomena his laboratory was burned, and before his work was thoroughly resumed in his new laboratory Roentgen's discovery was announced.

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The Western Telephone Construction Company Again Victorious — Court Decides Roosevelt Patent Has Not Been Infringed by Defendants.

In the United States District Court at Chicago Judge Grosscup, on the 5th instant, handed down a decision in favor of the Western Telephone Construction Company in the suit brought by the Western Electric Company in October, 1895, alleging infringement of the famous Roosevelt switch, patent No. 215,837, May 27, 1879, under which the Bell company is said to have paid during the life of the patent some $35,000 in royalties to the Roosevelt heirs. The court's decision was subsequently withdrawn for the purpose of revision as to its phraseology. The court held, in effect, that the Roosevelt device was a purely automatic switch; that is, a switch which would operate, without any intent of the operator, to make a change in the circuits, while the defendants' switch, which is identical with the Watson device (the patent on which was declared invalid on February 10 last), was not entirely automatic. In fact, it could not be called automatic in any sense, since the telephone had to be placed on the hook, and if not so placed, the circuit would not be changed, as in the Roosevelt device, where the hand 'phone was suspended by a cord, and the weight of the telephone was the real cause of changing the switch.

The suit has been in the courts for some time, and was earnestly contested on each side, its final outcome reflecting much credit on the argument of defendants' solicitor, Col. S. S. Stout.

[illegible] subject, and particularly on [illegible] of importance which I have [illegible]ed some time ago by the aid of such a Lenard tube, and which, if I am correctly informed, I can only in part consider as my own, since it seems that practically it has been expressed in other words by Professor Roentgen in a recent communication to the Academy of Sciences of Berlin. The result alluded to has reference to the much disputed question of the source of the Roentgen rays. As will be remembered, in the first announcement of his discovery, Roentgen was of the opinion that the rays which affected the sensitive layer emanated from the fluorescent spot on the glass wall of the bulb; other scientific men next made the cathode responsible; still others the anode, while some thought that the rays were emitted solely from fluorescent powders or surfaces, and speculations, mostly unfounded, increased to such an extent that, despairingly, one would exclaim with the poet:

"O gluecklich wer noch hoffen kann,
Aus diesem Meer des Irrtums aufzutauchen!"

My own experiments led me to recognize that, regardless of the location, the chief source of these rays was the place of the *first* impact of the projected stream of particles within the bulb. This was merely a broad statement, of which that of Professor Roentgen was a special case, as in his first experiments the fluorescent spot on the glass wall was, incidentally, the place of the first impact of the cathodic stream. Investigations carried on up to the present day have only confirmed the correctness of the above opinion, and the place of the first collision of the stream of particles—be it an anode or independent impact body, the glass wall or an aluminum window—is still found to be the principal source of the rays. But, as necessary to first show that there is an actual penetration of the particles through the wall, or otherwise that the actions of the supposed streams, of whatever nature they might be, were sufficiently pronounced in the outer region close to the wall of the bulb as to produce some of the effects which are peculiar to a cathodic stream. It was not difficult to obtain with a properly prepared Lenard tube, having an exceedingly thin window, many and at first surprising evidences of this character. Some of these have already been pointed out, and it is thought sufficient to cite here one more which I have since observed. In the hollow aluminum cap A of a tube as shown in diagram Fig. 1, which will be described in detail, I placed a half-dollar silver piece, supporting it at a small distance from and parallel to the window or bottom of the cap by strips of mica in such a manner that it was not

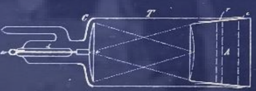

Fig. 2.—Improved Lenard Tube.

touching the metal of the tube, an air space being left all around it. Upon exciting the bulb for about 30 to 45 seconds by the secondary discharge of a powerful coil of a novel type now well known, it was found that the silver piece was rendered so hot as to actually scorch the hand; yet the aluminum window, which offered a very insignificant obstacle to the cathodic stream, was only moderately warmed. Thus it was shown that the silver alloy, owing to its density and thickness, took up most of the energy of the impact, being acted upon by the particles almost identically as if it had been

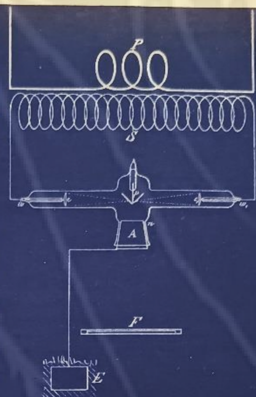

Fig. 3.—Illustrating Arrangement with Improved Double-Focus Tube for Reducing the Injurious Actions.

improved design, consisting of a tube T of thick glass tapering towards the open end, or neck n, into which is fitted an aluminum cap A, and a spherical cathode e, supported on a glass stem s, and platinum wire w sealed in the opposite end of the tube as usual. The aluminum cap A, as will be observed, is not in actual contact with the ground-glass wall, being held at a small distance from the latter by a narrow and continuous ring of tinfoil r. The outer space between the glass and the cap A is filled with cement c, in a manner which I shall later describe. F is a Roentgen screen such as is ordinarily used in making the observations.

Now, in looking upon the screen in the direction from F to T, the dark lines indicated on the lower part of the diagram were seen on the illuminated background. The curved line material was proceeding from the space outside of the bulb towards the aluminum cap, and chiefly from the region through which the primary disturbances or streams emitted from the tube through the window were passing, which observation could not be explained in a more plausible manner than by assuming that the air and dust particles outside, in the path of the projected streams, afforded an obstacle to their passage and gave rise to impacts and collisions spreading through the air in all directions, thus producing continuously new sources of the rays. It is this fact which, in his recent communication before mentioned, Roentgen has brought out. So, at least, I have interpreted his reported statement that the rays emanate from the irradiated air. It now remains to be shown whether the air, from which carefully all foreign particles are removed, is capable of behaving as an impact body and source of the rays, in order to decide whether the generation of the latter is dependent on the presence in

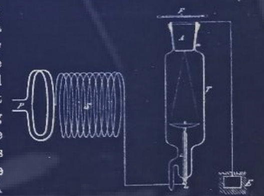

Fig. 4.—Illustrating Arrangement with a Lenard Tube for Safe Working at Close Range.

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With the knowledge of this fact we are now able to form a more general

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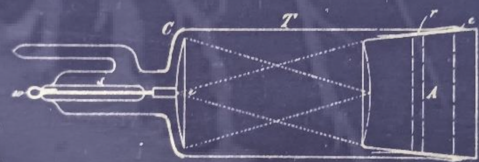

FIG. 2.—IMPROVED LENARD TUBE.

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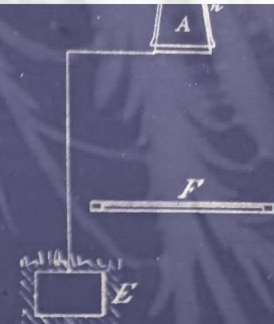

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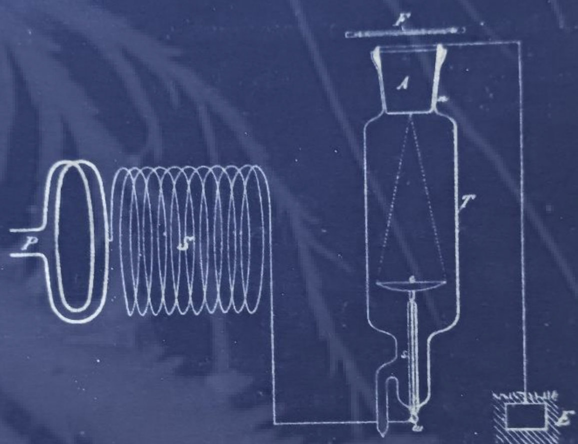

FIG. 4.—ILLUSTRATING ARRANGEMENT WITH A LENARD TUBE FOR SAFE WORKING AT CLOSE RANGE.

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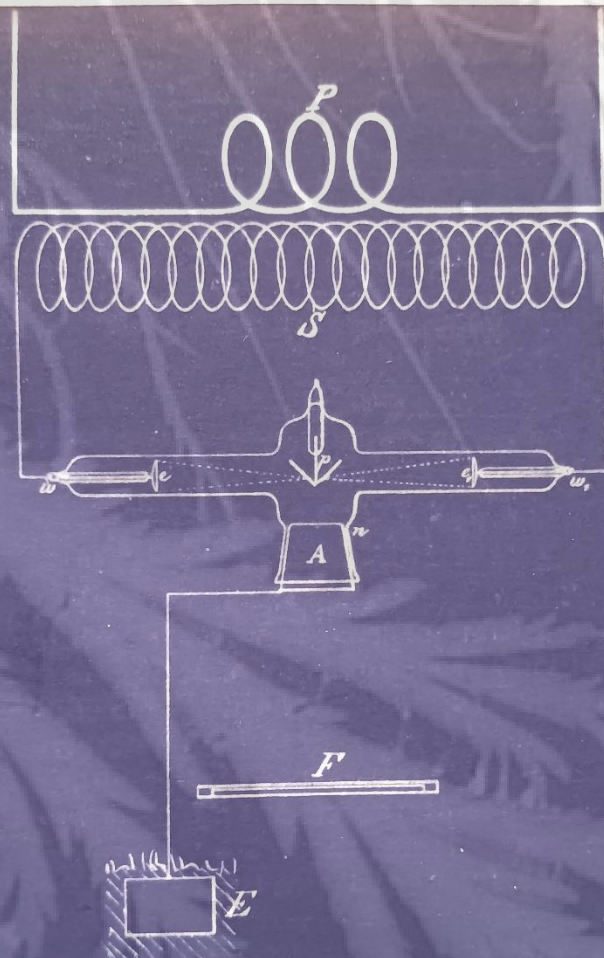

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TESLA ON ROENTGEN RAYS.

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idea of the process of generation of the radiations which have been discovered by Lenard and Roentgen. It may be comprised in the statement that the streams of minute material particles projected from an electrode with great velocity in encountering obstacles wherever they may be, within the bulb, in the air or other medium or in the sensitive layers themselves, give rise to rays or radiations possessing many of the properties of those known as light. If this physical process of generation of these rays is undoubtedly demonstrated as true, it will have most important consequences, as it will induce physicists to again critically examine many phenomena which are presently attributed to transverse ether waves, which may lead to a radical modification of existing views and theories in regard to these phenomena, if not as to their essence so, at least, as to the mode of their production.

My effort to arrive at an answer to the third of the above questions led me to the establishment, by actual photographs, of the close relationship which exists between the Lenard and Roentgen rays. The photographs bearing on this point were exhibited at a meeting of the New York Academy of Sciences—before referred to—April 6, 1897, but, unfortunately, owing to the shortness of my address, and concentration of thought on other matters, I omitted what was most important; namely, to describe the manner in which these photographs were obtained, an oversight which I was able to only partially repair the day following. I did, however, on that occasion illustrate and describe experiments, in which was shown the deflectibility of the Roentgen rays by a magnet, which establishes a still closer relationship, if not identity, of the rays named described, in which the primary is operated by the discharges of a condenser. With such an instrument any desired suddenness of the impulses may be secured, there being practically no limit in this respect, as the energy accumulated in the condenser is the most violently explosive agent we know, and any potential or electrical pressure is obtainable. Indeed, I found that in increasing the suddenness of the electro motive impulses through the tube—without, however, increasing, but rather diminishing the total energy conveyed to it—phosphorescence was observed and rays began to appear, first the feebler Lenard rays and later, by pushing the suddenness far enough, Roentgen rays of great intensity, which enabled me to obtain photographs showing the finest texture of the bones. Still, the same tube, when again operated with the ordinary coil of a low rate of change in the primary current, emitted practically no rays, even when, as before stated, much more energy, as judged from the heating, was passed through it. This experience, together with the fact that I have succeeded in producing, by the use of immense electrical pressures, obtainable with certain apparatus designed for this express purpose, some impressions in free air, have led me to the conclusion that in lightning discharges Lenard and Roentgen rays must be generated at ordinary atmospheric pressure.

At this juncture I realize, by a perusal of the preceding lines, that my scientific interest has dominated the practical, and that the following remarks must be devoted to the primary object of this communication—that is, to giving some data for the construction to those engaged in the manufacture of the tubes and, perhaps, a few useful hints to practicing physicians who are dependent on such information. The foregoing was, nevertheless, not lost for this object, inasmuch as it has shown how much the result obtained depends on the proper construction of the instruments, for, with ordinary implements, most of the above observations could outside, as is frequently done. Long experience has demonstrated that it is practically impossible to maintain a high vacuum in a tube with an outside cap. The only way I have been able to do this in a fair measure is by cooling the cap by a jet of air, for instance, and observing the following precautions: The air jet is first turned on slightly and upon this the tube is excited. The current through the latter, and also the air pressure, are then gradually increased and brought to the normal working condition. Upon completing the experiment the air pressure and current through the tube are both gradually reduced and both so manipulated that no great differences in temperature result between the glass and aluminum cap. If these precautions are not observed the vacuum will be immediately impaired in consequence of the uneven expansion of the glass and metal.

With tubes, as these presently described, it is quite unnecessary to observe this precaution if proper care is taken in their preparation. In inserting the cap the latter is cooled down as low as it is deemed advisable without endangering the glass, and it is then gently pushed in the neck of the tube, taking care that it sets straight.

The two most important operations in the manufacture of such a tube are, however, the thinning down of the aluminum window and the sealing in of the cap. The metal of the latter may be one thirty-second or even one-sixteenth of an inch thick, and in such case the central portion may be thinned down by a countersink tool about one-fourth of an inch in diameter as far as it is possible without tearing the sheet. The further thinning down may then be done by hand with a scraping tool; and, finally, the metal should be gently beaten down so as to surely close the pores which might permit a slow leak. Instead of proceeding in this way I have employed a cap with a hole in the center, which I have closed with a sheet of pure aluminum a few thousandths of an inch thick, riveted to the cap by means of a may be done first with acid, then with highly diluted alkali, next with distilled water, and finally with pure rectified alcohol.

These tubes, when properly prepared, give impressions much sharper and reveal much more detail than those of ordinary make. It is important for the clearness of the impressions that the electrode should be properly shaped, and that the focus should be exactly in the center of the cap or slightly inside. In fitting in the cap, the distance from the electrode should be measured as exactly as possible. It should also be remarked that the thinner the window, the sharper are the impressions, but it is not advisable to make it too thin, as it is apt to melt in a point on turning on the current.

The above advantages are not the only ones which these tubes offer. They are also better adapted for purposes of examination by surgeons, particularly if used in the peculiar manner illustrated in diagrams Fig. 3 and Fig. 4, which are self-explanatory. It will be seen that in each of these the cap is connected to the ground. This decidedly diminishes the injurious action and enables also to take impressions with very short exposures of a few seconds only at close range, inasmuch as, during the operation of the bulb, one can easily touch the cap without any inconvenience, owing to the ground connection. The arrangement shown in Fig. 4 is particularly advantageous with a form of single terminal, which coil I have described on other occasions and which is diagramatically illustrated, P being the primary and S the secondary. In this instance the high-potential terminal is connected to the electrode, while the cap is grounded. The tube may be placed in the position indicated in the drawing, under the operating table and quite close, or even in contact with the body of the patient, if the impression requires only a few seconds as, for instance, in examining parts of the members. I have taken many impressions with such tubes and have observed no injurious action, but I would advise not to expose

ON THE SOURCE OF ROENTGEN RAYS AND THE PRACTICAL CONSTRUCTION AND SAFE OPERATION OF LENARD TUBES.

To the Editor of Electrical Review:

I have for some time felt that a few indications in regard to the practical construction of Lenard tubes of improved designs, a great number of which I have recently exhibited before the New York Academy of Sciences (April 6, 1897), would be useful and timely, particularly as by their proper construction and use much of the danger attending the experimentation with the rays may be avoided. The simple precautions which I have suggested in my previous communications to your esteemed journal are seemingly disregarded, and cases of injury to patients are being almost daily reported, and in view of this only, were it for no other reason, the following lines, referring to this subject, would have been written before had not again pressing and unavoidable duties prevented me from doing so. A short and, I may say, most unwelcome interruption of the work which has been claiming my attention makes this now possible. However, as these opportunities are scarce, I will utilize the present to dwell in a few words on some other matters in connection with this subject, and particularly on a result of importance which I have reached some time ago by the aid of such a Lenard tube, and which, if I am correctly informed, I can only in part consider as my own, since it seems that practically it has been expressed in other words by Professor Roentgen in a recent communication to the Academy of Sciences of Berlin. The result alluded to has reference to the much disputed question of the source of the Roentgen rays. As will be remembered, in the first announcement

will be seen presently, it is not the only source.

Since recording the above fact my efforts were directed to finding answers to the following questions: First, is it necessary that the impact body should be within the tube? Second, is it required that the obstacle in the path of the cathodic stream should be a solid or liquid? And, third, to what extent is the velocity of the stream necessary for the generation of and influence upon the character of the rays emitted?

In order to ascertain whether a body located outside of the tube and in the

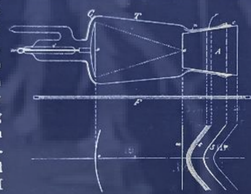
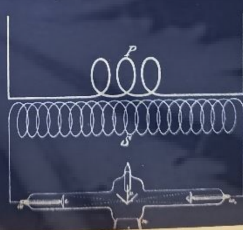


Fig. 1.—Illustrating an Experiment Revealing the Real Source of the Roentgen Rays.

path or in the direction of the stream of particles was capable of producing the same peculiar phenomena as an object located inside, it appeared necessary to first show that there is an actual penetration of the particles through the wall, or otherwise that the actions of the supposed streams, of whatever nature they might be, were sufficiently pronounced in the outer region close to the wall of the bulb as to produce some of the effects which are peculiar to a cathodic stream. It was not difficult to obtain with a properly prepared Lenard tube, having an exceedingly thin window, many and at first surprising evidences

inside of the bulb, and, what is more, indications were obtained, by observing the shadows, that it behaved like a second source of the rays, inasmuch as the outlines of the shadows, instead of being sharp and clear as when the half-dollar piece was removed, were dimmed. It was immaterial for the chief object of the inquiry to decide by more exact methods whether the cathodic particles actually penetrated the window, or whether a new and separate stream was projected from the outer side of the window. In my mind there exists not the least doubt that the former was the case, as in this respect I have been able to obtain numerous additional proofs, upon which I may dwell in the near future.

I next endeavored to ascertain whether it was necessary that the obstacle outside was, as in this case, a solid body, or a liquid, or broadly, a body of measurable dimensions, and it was in investigating in this direction that I came upon the important result to which I referred in the introductory statements of this communication. I namely observed rather accidentally, although I was following up a systematic inquiry, what is illustrated in diagram Fig. 1. The diagram shows a Lenard tube of



e and *e′* the straight line W were, of course, at once recognized as the outlines of the cathode *e* and the bottom of the cap A respectively, although, in consequence of a confusing optical illusion, they appeared much closer together than they actually were. For instance, if the distance between *e* and *o* was five inches, these lines would appear on the screen about two inches apart, as nearly as I could judge by the eye. This illusion may be easily explained and is quite unimportant, except that it might be of some moment to physicians to keep this fact in mind when making examinations with the screen as, owing to the above effect, which is sometimes exaggerated to a degree hard to believe, a completely erroneous idea of the distance of the various parts of the object under examination might be gained, to the detriment of the surgical operation. But while the lines *e* and W were easily accounted for, the curved lines *t*, *g*, *a* were at first puzzling. Soon, however, it was ascertained that the faint line *a* was the shadow of the edge of the aluminum cap, the much darker line *g* that of the rim of the glass tube T, and *t* the shadow of the tinfoil ring *r*. These shadows on the screen F clearly showed that the agency which affected the fluorescent material was proceeding from the space outside of the bulb towards the aluminum cap, and chiefly from the region through which the primary disturbances or streams emitted from the tube through the window were passing, which observation could not be explained in a more plausible manner than by assuming that the air and dust particles outside, in the path of the projected streams, afforded an obstacle to their passage and gave rise to impacts and collisions

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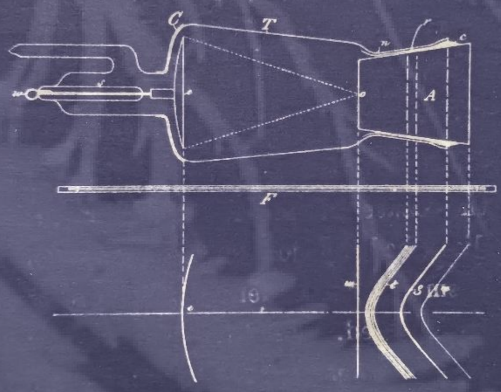

Fig. 1.—Illustrating an Experiment Revealing the Real Source of the Roentgen Rays.

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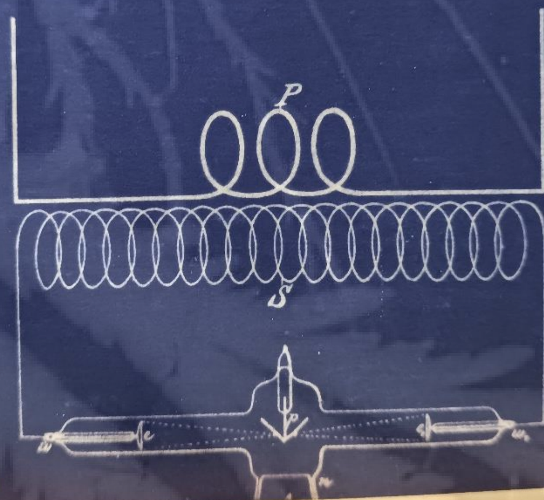

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...ing of the New York Academy of Sciences—before referred to—April 6, 1897, but, unfortunately, owing to the shortness of my address, and concentration of thought on other matters, I omitted what was most important; namely, to describe the manner in which these photographs were obtained; an oversight which I was able to only partially repair the day following. I did, however, on that occasion illustrate and describe experiments, in which was shown the deflectibility of the Roentgen rays by a magnet, which establishes a still closer relationship, if not identity, of the rays named after these two discoverers. But the description of these experiments in detail, as well as of other investigations and results in harmony with and restricted to the subject I brought before that scientific body, will appear in a longer communication which I am slowly preparing.

To bring out clearly the significance of the photographs in question, I would recall that, in some of my previous contributions to scientific societies, I have endeavored to dispel a popular opinion before existing that the phenomena known as those of Crookes were dependent on and indicative of high vacua. With this object in view, I showed that phosphorescence and most of the phenomena in Crookes bulbs were producible at greater pressures of the gases in the bulbs by the use of much higher or more sudden electro-motive impulses. Having this well demonstrated fact before me, I prepared a tube in the manner described by Lenard in his first classical communication on this subject. The tube was exhausted to a moderate degree, either by chance or of necessity, and it was found that, when operated by an ordinary high-tension coil of a low rate of change in the current, no rays of any of the two kinds could be detected, even when the tube was so highly strained as to become very hot in a few moments. Now, I expected that, if the suddenness of the impulses through the bulb were sufficiently increased, rays would be emitted. To test this I employed a coil of a type which I have repeatedly

push of the preceding lines, that my scientific interest has dominated the practical, and that the following remarks must be devoted to the primary object of this communication—that is, to giving some data for the construction to those engaged in the manufacture of the tubes and, perhaps, a few useful hints to practicing physicians who are dependent on such information. The foregoing was, nevertheless, not lost for this object, inasmuch as it has shown how much the result obtained depends on the proper construction of the instruments, for, with ordinary implements, most of the above observations could not have been made.

I have already described the form of tube illustrated in Fig. 1, and in Fig. 2 another still further improved design is shown. In this case the aluminum cap A, instead of having a straight bottom as before, is shaped spherically, the center of the sphere coinciding with that of the electrode *e*, which itself, as in Fig. 1, has its focus in the center of the window of cap A, as indicated by the dotted lines. The aluminum cap A has a tinfoil ring *r*, as that in Fig. 1, or else the metal of the cap is spun out on that place so as to afford a bearing of small surface between the metal and the glass. This is an important practical detail as, by making the bearing surface small, the pressure per unit of area is increased and a more perfect joint made. The ring *r* should be first spun out and then ground to fit the neck of the bulb. If a tinfoil ring is used instead, it may be cut out of one of the ordinary tinfoil caps obtainable in the market, care being taken that the ring is very smooth.

In Fig. 3 I have shown a modified design of tube which, as the two types before described, was comprised in the collection I exhibited. This, as will be observed, is a double-focus tube, with impact plates of iridium alloy and an aluminum cap A opposite the same. The tube is not shown because of any originality in design, but simply to illustrate a practical feature. It will be noted that the aluminum caps in the tubes described are fitted inside of the necks and not

even one-sixteenth of an inch thick, and in such case the central portion may be thinned down by a countersink tool about one-fourth of an inch in diameter as far as it is possible without tearing the sheet. The further thinning down may then be done by hand with a scraping tool; and, finally, the metal should be gently beaten down so as to surely close the pores which might permit a slow leak. Instead of proceeding in this way I have employed a cap with a hole in the center, which I have closed with a sheet of pure aluminum a few thousandths of an inch thick, riveted to the cap by means of a washer of thick metal, but the results were not quite as satisfactory.

In sealing the cap I have adopted the following procedure: The tube is fastened on the pump in the proper position and exhausted until a permanent condition is reached. The degree of exhaustion is a measure of perfection of the joint. The leak is usually considerable, but this is not so serious a defect as might be thought. Heat is now gradually applied to the tube by means of a gas stove until a temperature up to about the boiling point of sealing wax is reached. The space between the cap and the glass is then filled with sealing wax of good quality; and, when the latter begins to boil, the temperature is reduced to allow its settling in the cavity. The heat is then again increased, and this process of heating and cooling is repeated several times until the entire cavity, upon reduction of the temperature, is found to be filled uniformly with the wax, all bubbles having disappeared. A little more wax is then put on the top and the exhaustion carried on for an hour or so, according to the capacity of the pump, by application of moderate heat much below the melting point of the wax.

A tube prepared in this manner will maintain the vacuum very well, and will last indefinitely. If not used for a few months, it may gradually lose the high vacuum, but it can be quickly worked up. However, if after long use it becomes necessary to clean the tube, this is easily done by gently warming it and taking off the cap. The cleaning

I have described on other occasions and which is diagramatically illustrated, P being the primary and S the secondary. In this instance the high-potential terminal is connected to the electrode, while the cap is grounded. The tube may be placed in the position indicated in the drawing, under the operating table and quite close, or even in contact with the body of the patient, if the impression requires only a few seconds as, for instance, in examining parts of the members. I have taken many impressions with such tubes and have observed no injurious action, but I would advise not to expose for longer than two or three minutes at very short distances. In this respect the experimenter should bear in mind what I have stated in previous communications. At all events it is certain that, in proceeding in the manner described, additional safety is obtained and the process of taking impressions much quickened. To cool the cap, a jet of air may be used, as before stated, or else a small quantity of water may be poured in the cap each time when an impression is taken. The water only slightly impairs the action of the tube, while it maintains the window at a safe temperature. I may add that the tubes are improved by providing back of the electrode a metallic coating C, shown in Fig. 3 and Fig. 4.

NIKOLA TESLA.

New York, August 9.

Electric Light Plant Wanted.

Mr. T. J. Lillard, treasurer of the Elkin Manufacturing Company, of Elkin, Surry County, N. C., manufacturers of cotton yarns, twines, etc., writes to the ELECTRICAL REVIEW, under date of August 7, as follows:

"We want prices and estimates on a 400-light incandescent dynamo, switchboard, wire and everything used, to light the town of Elkin with, say 100 16-candle-power street lights, and for 30 stores and residences with eight lights each.

Tesla's Aerial Power Transmission.

To the Editor of Electrical Review:

This end of the century has been so replete with scientific discoveries, both electrical and otherwise, that the old motto, *nil admirari*, becomes revivified, and truly we wonder at nothing.

When one reads the account of Mr. Tesla's latest work in electric power transmission the mental question arises, "and why not?" Once he had accomplished wireless telegraphy, to his restless activity it was but a step to wireless transmission, merely devising ways and means for transmitting wagonloads instead of thimblefuls.

Nature herself has done this in what is probably her most awe-inspiring manifestation of power, the lightning. Who has not seen the tremendous bolt dart from one end of a long cloud to earth and at the other end flash back from earth, as the "return stroke?" And who will say the cloud, though many miles in length, has not constituted an aerial circuit in such case?

It is my belief that the upper strata are constantly carrying electrical currents of high potential.

An old-fashioned apparatus for the study of electrical phenomena was a globe of sulphur or glass, which, when rotated under slight friction of the dry hands, produced the desired effect in the shape of a snappy spark. Such a globe was about one foot diameter. What, then, should be the effect of the earth rotating at its enormous speed under the friction of the atmosphere—a globe billions of times the surface of the archaic electric machine?

It is no wonder that our most advanced meteorologists go astray in their forecasts, when they have no means of learning what is going on in the upper strata.

Tesla's balloon terminals may prove a boon to meteorology, while serving their own purpose also; for they can be used as a source of information of the various phenomena continually taking place above us. And, as the Electrical Review has often pointed out, meteorology will never reach the pedestal of an exact science till observations are regularly conducted at an elevation consistent with the conditions.

There is nothing inconceivable in Tesla's transmission scheme, wonderful as it may seem; on the contrary, it is consistent with all that has gone before. He has simply gone after tarpon when others have been content with sprats.

T. J. M.

New York, October 29.

John Stephenson ... Receivers' ...

Great surprise throu... trical industry and th... ness world was occa... failure last week of th... enson Company, ma... street cars in New Y... company is the oldes... business, and built the... ever used. On the aff... dent Davis and Secre... to the effect that th... temporarily embarra... Cohen appointed Alb... of Paterson, N. J., an... of New York, receiver... pany, under bonds of ...

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Import Duty on ... Lamps.

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...DAL REVIEW

A NEW MARVEL.

As we go to press an invention of Tesla's is announced which must produce a profound impression all over the world. Tesla has already identified himself with a number of most remarkable scientific advances, and great things may still be confidently expected as the fruit of his earnest and persistent labors, but it is difficult for us to see how he could ever produce a more beautiful result than he now makes known through a United States patent issued this week.

To direct and control to the minutest detail, by a subtle agent, the operations of a mechanism however complicated and ponderous, to change its speed and direction at will, to make it perform an unlimited number of movements, without any tangible connection and from a great distance, is indeed an achievement worthy of the closing days of this century of wonders.

When Bell transmitted the human voice over a wire so that the faintest of its modulations could be recognized, it was a marvelous triumph; when Edison showed his fascinating invention of the phonograph, this, too, was justly looked upon as a wonder; when Tesla first showed the phenomena of the rotating magnetic field, or when he presented the magical effect of a tube of glass brilliantly lighted in his hand, the world stood astonished; when Roentgen announced the epoch-making discovery of the rays bearing his name, the scientific world was thrilled as never before; but we believe that the beauty and importance of the invention Tesla has just announced, in its ultimate developments, will be such as to place it among the most potent fac-

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Tesla first showed ... the rotating magnetic field, or when he presented the magical effect of a tube of glass brilliantly lighted in his hand, the world stood astonished; when Roentgen announced the epoch-making discovery of the rays bearing his name, the scientific world was thrilled as never before; but we believe that the beauty and importance of the invention Tesla has just announced, in its ultimate developments, will be such as to place it among the most potent factors in the advance and civilization of mankind. The fact that the invention has been thoroughly and practically developed makes its immediate application sure.

In this issue we begin the publication of the clear and exhaustive wording of Tesla's own description of this invention, which will be concluded next week.

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THE EARTH AND ITS ATMOSPHERE.

A CRITICISM AND ITS ANSWER.

AN INQUIRY.

To the Editor of Electrical Review:

In your issue of November 2, in an article dated New York, October 29, and entitled "Tesla's Aerial Power Transmission," T. J. M. says: "What, then, should be the effect of the earth rotating at its enormous speed *under the friction of the atmosphere*—a globe billions of times the surface of the archaic electric machine?"

If I am not mistaken, there is no "friction of the atmosphere" *with the earth*. The atmosphere moves with the earth. Did it not, we should be swept from its surface by the enormous velocity of our motion through the atmosphere.

There is no friction at the "*upper*" surface of the atmosphere, for there is absolutely nothing to cause friction.

It seems to me that T. J. M. must seek another explanation of the source of electricity that causes the electrical phenomena of the atmosphere.

capable of giving astonishing electrical manifestations, and in the upper strata electrical excitement of a most intense character would not, if manifested, cause any surprise to the modern thinker. What is a storm, if it be not a condition attended by the friction of the lower strata upon the earth's surface, and probably of the lower strata against the higher strata of air? Yet the storm may be, and often is, raging furiously over an area of a million square miles or more.

In the absence of the right sort of data, namely, observations and records of what is going on away up in our atmosphere, no one can say what is the primary cause of these great areas of high and low pressure.

Many days one can look up and observe several strata of clouds, each layer moving in an independent direction, proving the existence of stratum-friction, the clouds being merely the finger-boards or pointers, and having no relation to or bearing upon the fact of independently moving layers of air and the friction necessarily could generate stupendous amounts of electricity. And it is quite as easy to believe—indeed, it would seem necessary to believe—that there are in the atmosphere movements just like the ocean tides, since air is as subject as water to the laws of gravitation.

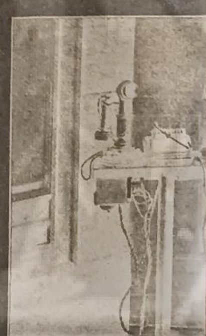
T. J. M.

New York, November 12.

Fig. 3.—Bookkeeping Department Equipped with Stromberg-Carlson Desk Telephones.

An Extensive Interior Telephone System.

An unusually large and conveniently arranged intercommunicating telephone system has recently been installed by the Stromberg-Carlson Telephone Manufacturing Company, of Chicago, in the new offices of the People's Gas Light and Coke Company, Michigan avenue and Adams street, Chicago. This modern plant affords a good example of the extent of the use and convenience of private telephone systems. In Fig. 2 is shown an interior view of one of



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THE EARTH AND ITS ATMOSPHERE.

A CRITICISM AND ITS ANSWER.

AN INQUIRY.

To the Editor of Electrical Review:

In your issue of November 2, in an article dated New York, October 29, and entitled "Tesla's Aerial Power Transmission," T. J. M. says: "What, then, should be the effect of the earth rotating at its enormous speed *under the friction of the atmosphere*—a globe billions of times the surface of the archaic electric machine?"

If I am not mistaken, there is no "friction of the atmosphere" *with the earth*. The atmosphere moves with the earth. Did it not, we should be swept from its surface by the enormous velocity of our motion through the atmosphere.

There is no friction at the "*upper*" surface of the atmosphere, for there is absolutely nothing to cause friction.

It seems to me that T. J. M. must seek another explanation of the source of electricity that causes the electrical phenomena of the atmosphere.

capable of giving astonishing electrical manifestations, and in the upper strata electrical excitement of a most intense character would not, if manifested, cause any surprise to the modern thinker. What is a storm, if it be not a condition attended by the friction of the lower strata upon the earth's surface, and probably of the lower strata against the higher strata of air? Yet the storm may be, and often is, raging furiously over an area of a million square miles or more.

In the absence of the right sort of data, namely, observations and records of what is going on away up in our atmosphere, no one can say what is the primary cause of these great areas of high and low pressure.

Many days one can look up and observe several strata of clouds, each layer moving in an independent direction, proving the existence of stratum-friction, the clouds being merely the finger-boards or pointers, and having no relation to or bearing upon the fact of independently moving layers of air and the friction necessarily could generate stupendous amounts of electricity. And it is quite as easy to believe—indeed, it would seem necessary to believe—that there are in the atmosphere movements just like the ocean tides, since air is as subject as water to the laws of gravitation.

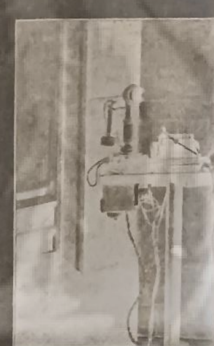
T. J. M.

New York, November 12.

FIG. 3.—BOOKKEEPING DEPARTMENT EQUIPPED WITH STROMBERG-CARLSON DESK TELEPHONES.

An Extensive Interior Telephone System.

An unusually large and conveniently arranged intercommunicating telephone system has recently been installed by the Stromberg-Carlson Telephone Manufacturing Company, of Chicago, in the new offices of the People's Gas Light and Coke Company, Michigan avenue and Adams street, Chicago. This modern plant affords a good example of the extent of the use and convenience of private telephone systems. In Fig. 2 is shown an interior view of one of



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TRANSMISSION OF POWER THROUGH THE AIR WITHOUT WIRES.

BY PROF. JOHN TROWBRIDGE IN THE "SCIENTIFIC AMERICAN."

Mr. Tesla has recently patented a method of transmitting power through the air without the use of wires. This method consists in producing a very great difference of potential between a high point in the atmosphere, reached by a wire connected to a balloon, and a distant point on a balloon, which in turn is connected through a step-down transformer with the earth. A step-up transformer produces the high potential at the sending station, or at the first balloon, and the difference of potential thus created produces a current of conduction through the rarefied air to the second balloon, and thence through the step-down transformer to

Fig. 1.—Sixty-Point Stromberg-Carlson Telephone Plug Box.

From both terminals, and from the conductors to those terminals, there is a luminous brush discharge to the walls and floor of the room. The main portion of the discharge is, so to speak, shunted through the air, which breaks down with facility at such high voltages. The high electro-motive force exerts a similar action to that of diminished air pressure.

In the case of rarefied air, one sees the luminous area of discharge on the positive terminal extend farther and farther from the point of the terminal, thus indicating that there is an increased flow through the rarefied and when the phenomenon is carefully examined, it is perceived that the disruptive sparks occur on the surface of the water inside the tubes, which vaporize the water and thus lead to an explosion. The layer of air conducts more readily than the water. The same phenomenon can be shown by interposing a conductor made of plumbago and infusorial earth, making a resistance of about 10,000 ohms between the terminals of the apparatus. A spark passes over the surface of such a conductor through the air, if the length of such a conductor does not exceed 10 or 12 inches.

I found also that the spark preferred to jump through five centimeters of air to passing through 1,000 ohms of a copper sulphate solution. Thus the air evidently breaks down with increasing readiness when the electro-motive force is increased beyond a certain limit.

One of the most striking experiments in this connection can be performed by coating a board with a thin layer of plumbago, which is polished upon the surface in such a manner as to make a resistance of about 1,000 ohms between broad terminal bands of copper. When a discharge under a difference of potential of 1,000,000 volts passes between the terminal entire apparatus lifted three feet from the floor. A certain portion of the loss was thus obviated, but when discharge takes place, sparks an inch long can be drawn from the neighboring brick walls, and the entire room seems to be filled with brush discharges.

I believe, therefore, that beyond 1,000,000 volts, the length of the spark is no longer proportional to the voltage, and that this departure from proportionality is due to the initial resistance of the neighboring air becoming less and less. In order to get the full effect of the voltage of my machine, I believe that it should be placed 30 or 40 feet above the earth and at a distance from neighboring masses. The apparent length of lightning discharges at low altitudes is therefore no criterion of the voltage which produces these discharges; for there must be great leakage, which necessitates an excess of electro motive force to produce the discharge. On the other hand, the discharges in higher regions of the atmosphere are much lengthened on account of the increased conductivity of the medium.

In view of the experiments which I have described, I am led to believe that ordinary atmospheric air under very high voltage acts like a fairly good conductor, and I can conceive of such a high electro motive force that the initial resistance of air might not be more than the resistance of

Fig. 1.—Sixty-Point Stromberg-Carlson Telephone Plug Box.

... without the use of wires. This method consists in producing a very great difference of potential between a high point in the atmosphere, reached by a wire connected to a balloon, and a distant point on a balloon, which in turn is connected through a step-down transformer with the earth. A step-up transformer produces the high potential at the sending station, or at the first balloon, and the difference of potential thus created produces a current of conduction through the rarefied air to the second balloon, and thence through the step-down transformer to earth. Mr. Tesla relies upon the good conductivity of rarefied air to high electro-motive force.

Some recent experiments I have made with high electro-motive force are interesting in regard to the suggestion of Mr. Tesla, and are in continuation of those I described in the *Scientific American* for January 15, 1898. At that time my apparatus was capable of producing 1,200,000 volts. It can now produce 3,000,000.

Up to the point of 1,500,000 volts the length of the electrical discharge in air appears to be closely proportional to the electro-motive force. When this voltage is exceeded, the length of the spark no longer increases in proportion to this force, for instance, and electro-motive force of, approximately, 3,000,000 volts produces a spark of about seven feet in length, when it should excite one at least 10 feet long. The reason of this diminution is readily seen when the operation of my apparatus is examined in the dark.

motive force exerts a similar action to that of diminished air pressure.

In the case of rarefied air, one sees the luminous area of discharge on the positive terminal extend farther and farther from the point of the terminal, thus indicating that there is an increased flow through the rarefied air. In ordinary atmospheric air the same increase of electrical conductivity takes place under the action of great electro-motive force. When discharges produced by 1,000,000 volts or more are excited between terminals six feet apart, in tubes filled with water, the tubes are speedily burst,

One of the most striking experiments in this connection can be performed by coating a board with a thin layer of plumbago, which is polished upon the surface in such a manner as to make a resistance of about 1,000 ohms between broad terminal bands of copper. When a discharge under a difference of potential of 1,000,000 volts passes between the terminal bands, the entire surface of the conductor becomes luminous.

When my new apparatus was first set up, the coated surfaces of the Leyden jars were not more than a foot from the floor. On account of the great loss due to electrostatic induction, I determined to have the

discharges in higher regions of th[e] atmosphere are much lengthened o[n] account of the increased conductivit[y] of the medium.

In view of the experiments which I have described, I am led to believe that ordinary atmospheric air under very high voltage acts like a fairly good conductor, and I can conceive of such a high electro motive force that the initial resistance of air might not be more than the resistance of metals. The loss of electrical energy in producing difference of potential of 3,000,000 volts at a distance of 1[0] feet from the terminals of my machine is very great, and in employing such high voltages Mr. Tesla could only obviate great loss by lifting his entire generating apparatus far above the surface of the earth.

Fig. 2.—View of Office Equipped with Stromberg-Carlson Desk Telephones.

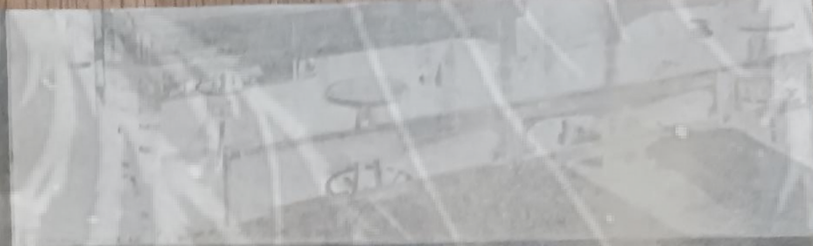

FIG. 3.—BOOKKEEPING DEPARTMENT EQUIPPED WITH STROMBERG-CA[illegible] DESK TELEPHONE

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There is no friction at the "*upper*" surface of the atmosphere, for there is absolutely nothing to cause friction.

It seems to me that T. J. M. must seek another explanation of the source of electricity that causes the electrical phenomena of the atmosphere.

S. R. M.

Ithaca, N. Y., November 4.

THE ANSWER.

To the Editor of Electrical Review:

If "S. R. M." had read discriminatingly he would have understood differ-ntly. As a whole, the earth and its atmosphere move together, or at least he text-books teach the student to onsider the fact settled. But there great disturbances constantly hapening in the air and over vast areas which can have tremendous effects earth's surface, and probably of the lower strata against the higher strata of air? Yet the storm may be, and often is, raging furiously over an area of a million square miles or more.

In the absence of the right sort of data, namely, observations and records of what is going on away up in our atmosphere, no one can say what is the primary cause of these great areas of high and low pressure.

Many days one can look up and observe several strata of clouds, each layer moving in an independent direction, proving the existence of stratum-friction, the clouds being merely the finger-boards or pointers, and having no relation to or bearing upon the fact of independently moving layers of air and the friction necessarily occurring.

And what is the cause of the steadily moving trade-winds in different parts of the world? Why is it that in a given locality the most destructive wind-storms always blow in the same direction? Text-books to the contrary, it is by no means demonstrated that there is no friction between the earth and its atmosphere. It is quite easy to conceive the idea of some friction; and easy to understand how the differential "winds" thus caused can take all sorts of directions. And a very little of that kind of disturbance

An Extensive Int[illegible]
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An unusually la[illegible] ently arranged in[illegible] telephone system [illegible] installed by the S[illegible] berg-Carlson Tele[illegible] Manufacturing Com[illegible] of Chicago, in the offices of the Pe[illegible] Gas Light and [illegible] Company, Michiga[illegible] nue and Adams [illegible] Chicago. This m[illegible] plant affords a go[illegible] ample of the exte[illegible] the use and conve[illegible] of private telephon[illegible] tems. In Fig. 2 is [illegible] an interior view of [illegible] the gas company's [illegible] cation offices on the floor, showing six [illegible] telephone instru[illegible] one at each windo[illegible] also three telephon[illegible] nected with the [illegible] exchange. Each [illegible] equipped with a [illegible] phone and a 60-p[illegible] that illustrated i[illegible] these instruments [illegible] nected with any [illegible] in the bookkeepi[illegible]

November 23, 1898

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A Letter From Mr. Tesla.

NEW YORK, Nov. 18, 1898.
46 and 48 East Houston St.

TO THE EDITOR OF ELECTRICAL REVIEW—*Dear Sir:*

Under enclosure I forward a copy of a letter which is self-explanatory. If you consider it a justice to me to insert it in your next issue, kindly do so.

Yours very truly,
N. TESLA.

"THE ELECTRICAL ENGINEER" ASKED TO EXPLAIN.

NEW YORK, Nov. 18, 1898.
46 and 48 East Houston St.

EDITOR OF THE ELECTRICAL ENGINEER—*Sir:*

By publishing in your columns of November 17 my recent contribution to the Electro-Therapeutic Society, you have finally succeeded—after many vain attempts made during a number of years—in causing me a serious injury. It has cost me great pains to write that paper, and I have expected to see it appear among other dignified contributions of its kind, and, I confess, the wound is deep. But you will have no opportunity for inflicting a similar one, as I propose to take better care of my papers in the future. In what manner you have secured this one in advance of other electrical periodicals, who had an equal right to the same, rests with the secretary of the society to explain.

Your editorial comment would not concern me in the least, were it not my duty to take note of it. On more than one occasion you have offended me, but in my qualities both as Christian and philosopher, I have always forgiven you and have only pitied you for your errors. This time, though, your offense is graver than the previous ones, for you have dared to cast a shadow on my honor.

No doubt you must have in your possession, from the illustrious men whom you quote, tangible proofs in support of your statement reflecting on my honesty. Being a bearer of high honors from a number of American universities, it is my duty, in view of the slur thus cast upon them, to exact from you that, in your next issue, you produce these, together with this letter which, in justice to myself, I am forwarding to other electrical journals. In the absence of such proofs, which would put me in the position to seek redress elsewhere, I require that, together with the preceding, you publish instead a complete and humble apology for your insulting remark which reflects on me as well as on those who honor me.

On this condition I will again forgive you, but I would advise you to limit yourself in your future attacks to statements for which you are not liable to be punished by law.

N. TESLA.

Mr. Charles A. Schott, chief of the ... Division of the Coast

PERSONAL

Mr. R. J. Randolph, manager of the Sterlin... Company, New York, ... York for a flying trip t...

Capt. T. H. Brady, of ... Ct., well known in ele... and one of the first ma... electrical goods, has b... member of the House ... tives of his state. Ca... many friends will con... and the state of Connec... of a capable and carefu...

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Mr. R. Edwards, J... & Company, New Yor... ing electricians, who ... an officer of the Sev... ment of New York d... paign, is now at his ... actively taking up hi... electrical field. Mr. ... of a number of gentl... volunteers from electr... ing the war who shed... entire fraternity by th... and patriotism.

Mr. F. E. Drake, ... Cleveland office of the... pany, has returned w... States Commission to... position and is now a... Astoria. Mr. Drake ... the position as chief o... cal and electrical dep... United States section... of the committee on ... office will be in Chica... make various trips o... commission-general.

Col. Jasper N. Kel... general manager of ... land Telephone and T... pany, was a New Y... week, after an abse... metropolis of nearly fo... nel Keller is one of ... in the telephone and ... and has developed his ... it is one of the solid ... the country. The ... sponsibilities of his ... tion have neither chan... ful temperament nor ... his friends in New Y... pleased to extend a c...

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No doubt you must have in your possession, from the illustrious men whom you quote, tangible proofs in support of your statement reflecting on my honesty. Being a bearer of high honors from a number of American universities, it is my duty, in view of the slur thus cast upon them, to exact from you that, in your next issue, you produce these, together with this letter which, in justice to myself, I am forwarding to other electrical journals. In the absence of such proofs, which would put me in the position to seek redress elsewhere, I require that, together with the preceding, you publish instead a

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Col. Jasper N. Kel... general manager of ... land Telephone and T... pany, was a New Y...

pressure all over its surface. It was nothing but what in mechanics is a pump, forcing water from a large reservoir into a small one and back again. Primarily I contemplated only the sending of messages to great distances in this manner, and I described the scheme in detail, pointing out on that occasion the importance of ascertaining certain electrical conditions of the earth. The attractive feature of this plan was that the intensity of the signals should diminish very little with the distance, and, in fact, should not diminish at all, if it were not for certain losses occurring, chiefly in the atmosphere. As all my previous ideas, this one, too, received the treatment of Marsyas, but it forms, nevertheless, the basis of what is now known as "wireless telegraphy." This statement will bear rigorous examination, but it is not made with the intent of detracting from the merit of others. On the contrary, it is with great pleasure that I acknowledge the early work of Dr. Lodge, the brilliant experiments of Marconi, and of a later experimenter in this line, Dr. Slaby, of Berlin. Now, this idea I extended to a system of power transmission, and I submitted it to Helmholtz on the occasion of his visit to this country. He unhesitatingly said that power could certainly be transmitted in this manner, but he doubted that I could ever produce an apparatus capable of creating the high pressures of a number of millions of volts, which were required to attack the problem with any chance of success, and that I could overcome the difficulties of insulation. Impossible as this problem seemed at first, I was fortunate to master it in a comparatively short time, and it was in perfecting this apparatus that I came to a turning point in the development of this idea. I, namely, at once observed that the air, which is a perfect insulator for currents produced by ordinary apparatus, was easily traversed by currents furnished by my improved machine, giving a tension of something like 2,500,000 volts. A further investigation in this direction led to another valuable fact; namely, that the conductivity of the air for these currents increased very rapidly with its degree of rarefaction, and at once the transmission of energy through the upper strata of the air, which, without such results as I have obtained, would be nothing more than a dream, became easily realizable. It appears all the more certain, as I find it quite practicable to transmit, under conditions such as [illegible]

Endeavoring to construct a mechanical model resembling in its essential, material features the human body, I was led to combine a controlling device, or organ sensitive to certain waves, with a body provided with propelling and directing mechanism, and the rest naturally followed. Originally the idea interested me only from the scientific point of view, but soon I saw that I had made a departure which sooner or later must produce a profound change in things and conditions presently existing. I hope this change will be for the good only, for, if it were otherwise, I wish that I had never made the invention. The future may or may not bear out my present convictions, but I can not refrain from saying that it is difficult for me to see at present how, with such a principle brought to great perfection, as it undoubtedly will be in the course of time, guns can maintain themselves as weapons. We shall be able, by availing ourselves of this advance, to send a projectile at much greater distance, it will not be limited in any way by weight or amount of explosive

velopment. It is in this feature, perhaps, more than in its power of destruction, that its tendency to arrest the development of arms and to stop warfare will reside. With renewed thanks, I remain,

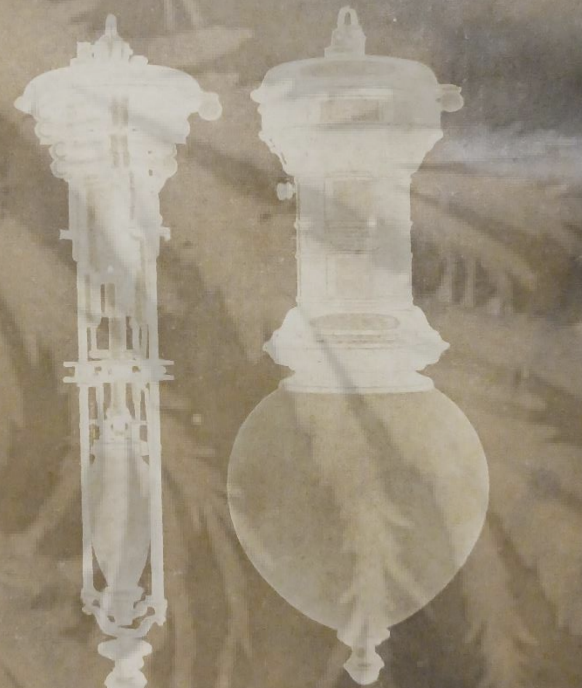
Very truly, yours,

N. TESLA.

New York, November 19.

220-Volt Enclosed Arc Lamp.

A perfected form of carbon feed arc lamp for direct connection across 220-volt mains, is being placed on the market by the Genetal Electric Company. It operates with 120 volts at the arc, takes a normal current of 2.5 amperes, and, with one trimming, has a life of from 130 to 150 hours, requiring no attention during that time. These carbons are so proportioned that the upper carbon at the end of any run of 130 or 150 hours may be placed in the lower carbon-holder for the next run.



A 220-VOLT ENCLOSED ARC LAMP.

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Referring to my latest invention, I wish to bring out a point which has been overlooked. I arrived, as has been stated, at the idea through entirely abstract speculations on the human organism, which I conceived to be a self-propelling machine, the motions of which are governed by impressions received through the eye. Endeavoring to construct a mechanical model resembling in its essential, material features the human body, I was led to combine a controlling device, or organ sensitive to certain waves, with a body provided with propelling and directing mechanism, and the rest naturally followed. Originally the idea interested me only from the scientific point of view, but soon I saw that I had made a departure which sooner or later must produce a profound change in things and conditions presently existing. I hope this change will be for the good only, for, if it were otherwise, I wish that I had never made the invention. The future may or may not bear out my present convictions, but I can not refrain from saying that it is difficult for me to see at present how, with such a principle brought to great perfection, as it undoubtedly will be in the course of time, guns can maintain themselves as weapons. We shall be able, by availing ourselves of this advance, to send a projectile at much greater distance, it will not be limited in any way by weight or amount of explosive charge, we shall be able to submerge it at command, to arrest it in its flight, and call it back, and to send it out again and explode it at will, and, more than this, it will never make a miss, since all chance in this regard, if hitting the object of attack were at all required, is eliminated. But the chief feature of such a weapon is still to be told; namely, it may be made to respond only to a certain note or tune, it may be endowed with selective power. Directly such an arm is produced, it becomes almost impossible to meet it with a corresponding development. It is in this feature, perhaps, more than in its power of destruction, that its tendency to arrest the development of arms and to stop warfare will reside. With renewed thanks, I remain,

Very truly, yours,

N. TESLA.

New York, November 19.

220-Volt Enclosed Arc Lamp.

A perfected form of carbon feed arc lamp for direct connection across 220-volt mains, is being placed on the market by the General Electric Company. It operates with 120 volts at the arc, takes a normal current of 2.5 amperes, and, with one trimming, has a life of from 130 to 150 hours, requiring no attention during that time. These carbons are so proportioned that the upper carbon at the end of any run of 130 or 150 hours may be placed in the lower carbon-holder for the next run. The light is of less volume and more violet in color than standard 110-volt lamps, but the advantages of a 220-volt lamp, capable of independent operation, sometimes compensates for the diminution of light as compared with the General Electric five ampere-power circuit lamp for use, two in series, across 220-volt mains. A variable resistance at the top of the mechanism allows the use of the lamp on circuits of from 210 to 250 volts, and disconnection from the circuit is

A 220-VOLT ENCLOSED ARC LAMP.

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send a projectile at much greater distance, it will not be limited in any way by weight or amount of explosive
upper carbon at the end of any run of 130 or 150 hours may be placed in the lower carbon-holder for the next run.

An Inquiry about Tesla's Electrically Controlled Vessel.

TO THE EDITOR OF ELECTRICAL REVIEW:

I have read some of the newspaper effusions relative to Mr. Nikola Tesla's latest invention, and have noted the articles and your editorial in the issue dated the 16th instant of your valued paper. In connection therewith permit me to inquire: Has not a very serious and important consideration in the operation of Mr. Tesla's apparatus been overlooked? It occurred to me that, while the vessel is controlled primarily by means of a "coherer" which receives the "waves" from the "transmitter" on shore, this same "coherer" can also be influenced by "waves" set up and transmitted *from the vessel menaced*, and the movements of the Tesla craft made uncontrollable. The Tesla vessel would, when nearer the vessel attacked, be within a stronger field of the radiations from the latter vessel's transmitter than from the controlling transmitter on shore or elsewhere. It will be necessary for Mr. Tesla to devise some method of control that can not be counter-influenced by the enemy.

Yours truly,

N. G. WORTH.

Indianapolis, November 21.

Wonderful Tale of an Electric Snow Storm in Mexico.

[*From the Monterey, Mex., Globe.*]

Lieutenant Finley's description of the night he passed on Pike's Peak in an electric snow-storm contains some picturesque and spectacular details. He speaks of the storm as "a shower of cold fire." The snowflakes were at first ordinary flakes, falling lightly and silently, but soon they became charged with electricity, and as each one fell on the hair of the mule the lieutenant was riding it gave out a tiny spark. The mule soon

AN ANALYSIS OF TESLA'S WORK.

SOME NON-TECHNICAL VIEWS AND A RESPONSE BY TESLA DESCRIBING HIS EFFORTS IN SEVERAL FIELDS OF WORK.

The articles published below are taken from the New York *Sun*, a journal that is conservatively and ably conducted in all its scientific discussions. We consider its editorial review of Tesla's efforts and ambitions the best that has appeared, and Tesla's letter that follows will be read with interest by every one acquainted with modern electrical work. It is the first communication of this kind ever sent to the lay press by Tesla, who has been the victim of probably more forged interviews and sensational articles appearing without authority than any other inventor.

The *Sun* editorial is as follows:

NIKOLA TESLA AND HIS QUEST.

[*From The Sun, New York, November 18, 1898.*]

Nikola Tesla has just made public some facts about an invention intended to make war too terrible to be prosecuted, and thus to insure peace between nations. The war with Spain drew Mr. Tesla's mind aside for the time from the line of studies which has engaged him for years. Inspired and fired by patriotism, he has applied to a war engine some of the principles which he discovered in following his inquiries into new methods of applying energy to the purposes of peace.

The success or failure of Mr. Tesla's latest invention will not turn him away from the great project which has possessed his mind for years. This, as he puts it, is to harness the sun's power to do the work of mankind. He does not mean to catch the power of the sun's rays directly. for a distance of from 50 to 100 miles is hardly more useful than a reach of eight or ten miles. Mr. Tesla designs to annihilate space. He would take the power of a Niagara, transform it into an electric current, and send this without appreciable loss to any place on earth where it was needed for use. Mr. Tesla has, accordingly, devised an electric oscillator which will receive the electric current from its source and give it an intensity which, as the inventor calculates, would enable a copper thread to carry 50,000 horsepower across the ocean. Mr. Tesla claims to have discovered, furthermore, that at an altitude easily reached by balloons the rarefied air has a conductivity equal to copper, while the denser layer of air below is a non-conductor. He proposes to suspend one pole of his electric circuit in the air at Niagara Falls and the other at Paris, and to forward his current through the upper air to France, whence it shall return through the earth when its active energy has been expended in work. He believes that he will be able to make this demonstration in 1900 as an exhibit at the coming world's fair at Paris, and to drive all the machinery at that exposition with the power from our great waterfall. The significance of his success would be that coal would become a convenience instead of a necessity, and water power and electricity would replace coal and steam for the work of the world.

Another great quest which Mr. Tesla has been conducting side by side with this—and, in fact, leading along the same lines—is for the means of producing light from electricity without heat. It was well known when Tesla began his studies that a Crookes vacuum tube could be made to glow by passing through it currents of electricity at a high tension, but no electrician could evolve from these tubes more than a phosphorescent glow. To turn this into a white light which at will. Perhaps because none of these late triumphs of Mr. Tesla's genius have yet been brought into practical use, there are many persons who declare that he is a visionary and impractical. It must be remembered that his discovery of the rotating electric field was of as great importance in its day as are his later discoveries now. That was announced in 1882, yet it was nearly 10 years before its value was fully recognized.

The personality of Nikola Tesla is as interesting as are the results of his scientific labors. His ways of work differ radically from the methods of those who study by experiment and elimination. Tesla seldom experiments, and when he does it is to prove a theory, not to form one. In 11 years, he says, only one of his experiments has failed. His processes are mental, and at times, he declares, his mind reaches out into fields so vast that he is afraid, and recalls it. He verifies his conclusions afterward by figures and experiments.

No other great scientific genius ever turned aside from his work to devise means for putting an end to war. Others have invented guns, armor, explosives and other accessories of war, but even in these cases the inventions were in a line with work in which the inventors were already engaged. Mr. Tesla's first design was to apply his method of control to such engines as automobile torpedoes, and to use these to destroy the Spanish fleets, but as he went on, the broader idea came to him to make his war machine so irresistible as to render war itself improbable.

TESLA DESCRIBES HIS EFFORTS IN VARIOUS FIELDS OF WORK.

[*From The Sun, New York, November 21, 1898.*]

To the Editor of The Sun—Sir: Had it not been for other urgent duties, I would before this have ing a high vibration without going through the lower or fundamental tones. On purely theoretical grounds such a result is thinkable, but it would imply a device for starting the vibrations of unattainable qualities, inasmuch as it would have to be entirely devoid of inertia and other properties of matter. Though I have conceptions in this regard, I dismiss for the present this proposition as being impossible. We can not produce light without heat, but we can surely produce a more efficient light than that obtained in the incandescent lamp, which, though a beautiful invention, is sadly lacking in the feature of efficiency. As the first step toward this realization, I found it necessary to invent some method for transforming economically the ordinary currents as furnished from the lighting circuits into electrical vibrations of great rapidity. This was a difficult problem, and it was only recently that I was able to announce its practical and thoroughly satisfactory solution. But this was not the only requirement in a system of this kind. It was necessary also to increase the intensity of the light, which at first was very feeble. In this direction, too, I met with complete success, so that at present I am producing a thoroughly serviceable and economical light of any desired intensity. I do not mean to say that this system will revolutionize those in use at present, which have resulted from the co-operation of many able men. I am only sure that it will have its fields of usefulness.

As to the idea of rendering the energy of the sun available for industrial purposes, it fascinated me early, but I must admit it was only long after I discovered the rotating magnetic field that it took a firm hold upon my mind. In assailing the problem I found two possible ways of solving it. Either power was to be developed on the spot by co

some facts about an invention intended to make war too terrible to be prosecuted, and thus to insure peace between nations. The war with Spain drew Mr. Tesla's mind aside for the time from the line of studies which has engaged him for years. Inspired and fired by patriotism, he has applied to a war engine some of the principles which he discovered in following his inquiries into new methods of applying energy to the purposes of peace.

The success or failure of Mr. Tesla's latest invention will not turn him away from the great project which has possessed his mind for years. This, as he puts it, is to harness the sun's power to do the work of mankind. He does not mean to catch the power of the sun's rays directly, but to utilize that enormous portion of their power which is expended upon the earth's surface in sucking from sea and lake waters which are afterward precipitated upon the higher parts of the land.

That there are waterfalls upon the earth which are capable of producing all the energy which mankind uses for power, heat and light is well known. The use of water-powers, however, is limited within narrow margins, partly because of the investment cost of instalment, but chiefly because the great waterfalls are remote from the seats of population and trade. Before Mr. Tesla began his researches there was no method known by which the power generated at a remote place could be transmitted to where it was wanted except at a loss of efficiency which was prohibitory. Since that time, by the use of currents of from 10,000 to 20,000 volts, it has become possible to send electric power successfully over wires for 35 miles or more, and one plant is now building to transmit power 85 miles.

But to utilize the great water-powers of the world, the transmittal of energy sition with the power from our great waterfall. The significance of his success would be that coal would become a convenience instead of a necessity, and water-power and electricity would replace coal and steam for the work of the world.

Another great quest which Mr. Tesla has been conducting side by side with this—and, in fact, leading along the same lines—is for the means of producing light from electricity without heat. It was well known when Tesla began his studies that a Crookes vacuum tube could be made to glow by passing through it currents of electricity at a high tension, but no electrician could evolve from these tubes more than a phosphorescent glow. To turn this into a white light which should shine like the face of the sun itself was the problem to be solved. All his investigations led Mr. Tesla to conclude that the thing which was needed was to be able to give to electrical currents voltages enormously beyond any which had ever been produced, and then to be able to handle and control the currents thus transformed. From this need grew his electrical oscillator, with which Mr. Tesla proposes to produce a current with an intensity of 800,000 volts, capable of transmission across the Atlantic. In Mr. Tesla's laboratory the vacuum tubes glow like sunshine, and their introduction for use is waiting only for a reduction of the cost of their light to a commercial basis, a reduction which he says is near at hand.

Since Mr. Tesla began investigating the possibilities of such high-tension currents as he produces by means of his oscillator he has made some startling announcements, such as that of his ability to use the whole earth as a conductor, and to telegraph to any part of its surface from any other part, sending messages jointly to many stations, or separately to each, have invented guns, armor, explosives and other accessories of war, but even in these cases the inventions were in a line with work in which the inventors were already engaged. Mr. Tesla's first design was to apply his method of control to such engines as automobile torpedoes, and to use these to destroy the Spanish fleets, but as he went on, the broader idea came to him to make his war machine so irresistible as to render war itself improbable.

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[From The Sun, New York, November 21, 1898.]

TO THE EDITOR OF THE SUN—SIR: Had it not been for other urgent duties, I would before this have acknowledged your highly appreciative editorial of November 13. Such earnest comments and the frequent evidences of the highest appreciation of my labors by men who are the recognized leaders of this day in scientific speculation, discovery and invention are a powerful stimulus, and I am thankful for them. There is nothing that gives me so much strength and courage as the feeling that those who are competent to judge have faith in me.

Permit me on this occasion to make a few statements which will define my position in the various fields of investigation you have touched upon.

I can not but gratefully acknowledge my indebtedness to earlier workers, as Dr. Hertz and Dr. Lodge, in my efforts to produce a practical and economical lighting system on the lines which I first disclosed in a lecture at Columbia College in 1891. There exists a popular error in regard to this light, inasmuch as it is believed that it can be obtained without generation of heat. The enthusiasm of Dr. Lodge is probably responsible for this error, which I have pointed out early by showing the impossibility of reach- feeble. In this direction, too, I met with complete success, so that at present I am producing a thoroughly serviceable and economical light of any desired intensity. I do not mean to say that this system will revolutionize those in use at present, which have resulted from the co operation of many able men. I am only sure that it will have its fields of usefulness.

As to the idea of rendering the energy of the sun available for industrial purposes, it fascinated me early, but I must admit it was only long after I discoverd the rotating magnetic field that it took a firm hold upon my mind. In assailing the problem I found two possible ways of solving it. Either power was to be developed on the spot by converting the energy of the sun's radiations or the energy of vast reservoirs was to be transmitted economically to any distance. Though there were other possible sources of economical power, only the two solutions mentioned offer the ideal feature of power being obtained without any consumption of material. After long thought I finally arrived at two solutions, but on the first of these, namely, that referring to the development of power in any locality from the sun's radiations, I can not dwell at present. The system of power transmission without wires, in the form in which I have described it recently, originated in this manner. Starting from the two facts that the earth was a conductor insulated in space, and that a body can not be charged without causing an equivalent displacement of electricity in the earth, I undertook to construct a machine suited for creating as large a displacement as possible of the earth's electricity.

This machine was simply to charge and discharge in rapid succession a body insulated in space, thus altering periodically the amount of electricity in the earth, and consequently the

ANSWER TO AN INQUIRY CONCERNING TESLA'S LATEST INVENTION.

In the ELECTRICAL REVIEW last week appeared an inquiry from Mr. N. G. Worth, of Indianapolis, relating to a probable defect in the electrically-controlled vessel recently patented by Nikola Tesla. Mr. Worth inquired if the ship or fort menaced could not set up a counter-influence by means of similar apparatus, which would be more powerful at a nearer radiation than that transmitted to the attacking vessel from the distant point where the original and controlling influence was created. A number of electrical experts and the inventor himself have been consulted on this point, in addition to a careful perusal by the writer of the technical description of the invention which appeared in full exclusively in this journal on November 9 and 16. The following passage from the patent, in which the italics are our own, is republished as bearing on this question:

"It will be obviously noted from the preceding that, whichever of these or similar contrivances be used, the sensitiveness and, what is often still more important, the reliability of operation are very materially increased by a close adjustment of periods of vibration of the transmitting and receiving circuits, and, although such adjustment is in many cases unnecessary for the successful carrying out of my invention [Tesla evidently refers here to the many uses of his invention in peace—ED.] I nevertheless make it a rule to bestow on this feature the greatest possible care, not only because of the above-mentioned advantages, which are secured by the observance of the most favorable conditions in this respect, but also, and chiefly, with the object of *preventing the receiving circuit from being affected by waves or disturbances emanating from sources not under the control*

ing electrical waves of any pitch, still he would never be able to know which of the notes struck is affecting the circuit on the assailing vessel, since this effect would be only momentary and speedily counteracted by the sending apparatus which the operator guiding the vessel in its course is controlling.

But, quite apart from the above, let it be assumed that such adjustment of the sending and receiving circuits was not at all observed, and that no agents were known capable of affecting a sensitive device on the Tesla vessel, which agent, by its very nature, made it impossible for the enemy to ward off the attack. The latter supposition is manifestly untrue, since any radiation propagating in straight lines, as light or short Hertzian waves, may be used for operating the vessel, and such radiations may be screened off on the side towards the enemy, so that the latter could not affect the controlling device on the attacking vessel. Still, even in such an extreme case, it would seem to us that, while it might be easy to disturb the dot and dash signals in wireless telegraphy, it would be quite a different matter to prevent an operator from directing his vessel to wherever he desires, for *he* only would know precisely how the signals affect the mechanism, whereas the supposed opponent would have no knowledge whatever in this respect and could never tell whether, in working his apparatus, he is aiding or thwarting the efforts of his assailant. However, his signals would be of telling effect only after the assailing vessel had reached a point at which

tions? And anyway, how is he to know to what kind of influence the controlling device on the assailing vessel is designed to respond? And granted he does, will he feel sure to start his apparatus going when there might be a vessel submerged in the neighborhood responsive to his signals and ready to ignite a great quantity of explosive, and to so annihilate his costly ship and living crew? How would he know that, by his own signals, he is not drawing upon his ship one of the vessels especially adapted for such purpose, thus bringing destruction upon himself through his very efforts to ward off the danger? Would he not expose himself to such liabilities, particularly at night? A great many more of such arguments might be made if they were needed, and all of this, it seems to us, has been overlooked in the various comments we have perused. It is well known that most of the naval engagements must of necessity take place near the coast. Now it is not difficult to employ on shore a sending apparatus, fixed or portable, of great power, against which any on board of a warship would be ineffective, and we ask again how could a commander of a fleet possibly venture to approach the coast within 10 or 15 miles when he would know that in so doing he is risking not one but all of his vessels?

Our inquirer is mistaken in the belief that the use of the coherer is indispensable in Tesla's invention. The inventor is very explicit on this point, as will be observed by perusing his text. To cite only one passage, he states:

"A great variety of electrical and other devices, more or less suitable for the purpose of detecting and utilizing feeble actions, are now well known to scientific men and artisans, and need not be all enumerated here. Confining myself merely to the electrical * * *"

Those who have criticized this im-

tific men of old, like Archimedes. He must have known, for instance, that by striking a shrill note he could set into vibration a delicate reed or diaphragm at a distance of as much as two or three miles, and he might have known that the force so developed could be utilized, in many ways, to control the movements of a rudder or other device on a vessel, and that by such control the vessel could be guided upon the enemy's ship and the latter destroyed, as by ramming into it, or by causing, for example, a large quantity of inflammable fluid to flow on the water and then igniting the fluid through a contrivance actuated by the signal from a distance, far out of the reach of the enemy's weapons. When gunpowder was discovered, and when we gained knowledge of voltaic electricity, it became still more easy to carry out the idea. When the action of light on a selenium cell was observed, a simple means was offered for effecting the control at great distances. The observation that currents are propagated through the ground to considerable distances and that inductive effects take place between circuits widely apart, again enlarged the possibilities, until finally the science of electrical vibrations and synchronized circuits afforded the best means for carrying the idea into practice. These means, which are accessories in this invention, will, in all probability, multiply and be further improved as time goes on, and, with every advance in this direction, this new art will be brought to greater perfection.

To one who considers that for centuries past a large proportion of human effort has been spent in devising and producing the most efficient means for destroying an enemy, the tremendous importance of this new departure is instantly impressive. The weapon is no longer one depend-

ith welded ends, and he also heated e working cylinders to prevent eezing of the valves. His car oper- ed "successfully on the Whitney- le road, and ran at times about ice as rapidly as a horse car."

Here are about all the features of velty that can be asserted of the otor system in process of adoption the Twenty-eighth and Twenty- nth street line, and yet we are told is brand new and will be highly ccessful.

On one hand we are told that the motor is really successful at last, er all these years of alleged success- trial; that it is owned by a power- clique and is to be forced upon the tropolitan Street Railway Com- ... the everlasting fattening of

were placed on the market. The electric light pioneers will all remember the sensation they created. It was the beginning of an entirely new departure in the field of illumination.

A New England college professor gravely writes that he does not believe Tesla can operate his teledynamic vessel by "mere act of his will." No one does, and Tesla least of all. Before accusing this inventor of making such a remark, the educator might at least have tried to have it confirmed or denied.

In another column a correspondent of the ELECTRICAL REVIEW advances the novel idea of employing electric automobiles for hauling carts used in removing the snow from city streets. The fact that, during the recent blizzard, the electric cabs in New York

The Genius of Destruction.

[*Translated from "L'Evenément."*]

Man is born a vandal. His instinctive joy, his first pleasure is to destroy. From the reminiscences of his primitive savagery, throughout the process of civilization, this barbarous atavism which incites him to destruction and strife adheres to him. War, apart from the sacred causes which arise from the right of legitimate defense, is often nothing else than a manifestation of this instinct. It seems that Man, in imitation of Nature, and even oftener than Nature, offers an example, wants to create cataclysms in obeyance to this fatal heredity. His very genius provokes or produces them; for, since it is a question of catastrophes, the ambition of his knowledge knows no limits, and, devoured by the spirit of Evil, he perfects his engines of disaster and ruin.

Thus Nikola Tesla, a learned American, a rival of the illustrious Edison, has just made a discovery which, when applied to the art of warfare on sea or land, is to furnish to the armies a power of destruction so formidable that one scarcely dares to contemplate its practical results. The secret of this discovery resides in the transmission of electrical energy to distances which, until now, nobody could surmise. By simple atmospheric conduction, and without any wire whatever, the current is to traverse thousands of kilometers, bring mourning and desolation and carry death, silently, invisibly, into the ranks of the enemy, who will not even be aware of the approach of the Camarde and able to defend himself against its unforeseen blow.

It is with such exploits that human wisdom taxes its ingenuity, and one still dares to praise the moral effect of philosophy.

According to Nikola Tesla, the problem solved by him consists in producing and projecting currents of an enormous voltage heretofore unknown to electricians.

By means of this discovery an operator may, in the shelter of his laboratory, his person not exposed to the least danger, in perfect security blow up out at sea boats carrying explosives at incalculable distances and beyond the range of the most powerful guns.

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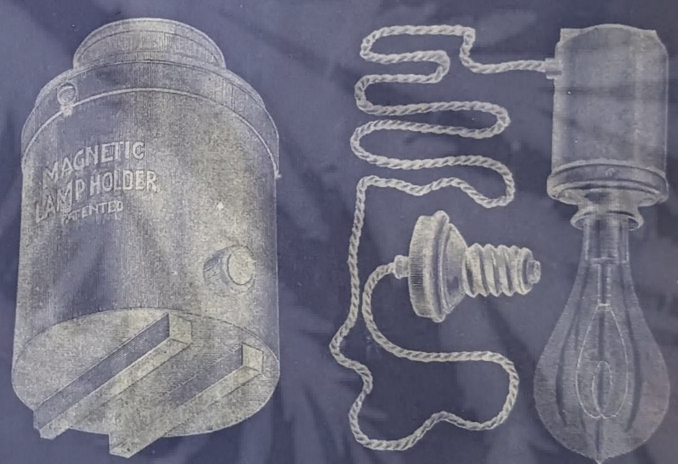
structed a small model of a boat which performs all the evolutions of his prescription. It is terrible in its precision. An electric motor placed at a distance, in another room, controls all its movements automatically and in a reliable manner. And in this way an electrician on board of a flagship seeming quite inoffensive may, with a simplicity which would eclipse the knowledge of the most profound strategists, direct against the enemy small vessels intended to spread death around themselves—death which nobody suspects, which calls unawares and from afar, with the prophetic surprise of a cataclysm prepared by man.

This is terrible, and causes one to shudder when contemplating this



FIGS. 1 AND 2.—A MAGNETIC INCANDESCENT LAMP HOLDER.

power of destruction brought to the height of its terror.

We must not be incredulous, however. Nikola Tesla proposes to instruct the most intellectual and skeptical people on earth. He intends to exhibit at the exposition in 1900 a torpedo of his invention. He will himself direct its movements from New York, without a conducting wire, by simple electric transmission through the high regions of the atmosphere.

And when we have been entertained what will be the result for humanity, thus threatened with the worst catastrophes, at the mercy of an infernal operator [illegible] with [illegible] almo[illegible]

this account Nikola Tesla claims a right to be called a benefactor of humanity.

Posterity will, perhaps, accord him this claim, as well as to others who have, like him, perfected the art of destroying in bulk and at wholesale, dreaming of such numbers of deaths that nobody would want to boast the tragic glory of ever having caused them.

The genius of destruction would seem to have, then, two aims. It creates evil, but mostly good. Through its help the abolition of wars may no longer be a utopia of generous dreamers, an empty dream of enlightened, altruistic thinkers who have compassion with their fellowmen. A blessed era will open up to the people,

whose quarrels will be settled in view of the terror of the cataclysms promised by science, views radiant with peace, which has at last conquered over centuries of barbarism, and there will be definite harmony in the entirely pacified universe!

What contradictions of conception is the human mind subject to? At the moment when, thanks to the magnanimous initiative of Czar Nicholas II, the problem of universal disarmament is attracting the attention, the solicitude, of the diplomats of all nations, an inventor, a physicist of the New World, promises us the end of the barbarous international [illegible] the tragical [illegible] of the

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By means of this discovery an operator may, in the shelter of his laboratory, his person not exposed to the least danger, in perfect security blow up out at sea boats carrying explosives at incalculable distances and beyond the range of the most powerful guns.

A simple unarmored, unprotected vessel, having not even a cannon on board, but capable of great speed, may become the most terrible adversary of a whole fleet. A single operator in command of a flotilla of small boats, the evolutions of which are controlled by him with mathematic precision, may destroy the enemy's squadrons without having himself run any risk. In the same manner, and with as little danger, he may send into the enemy's port explosives which would produce a disaster similar to an earthquake.

In order to cause the credit to be given to such prophecies to be appreciated, the learned Yankee has confessed the power of destruction brought to the height of its terror.

We must not be incredulous, however. Nikola Tesla proposes to instruct the most intellectual and skeptical people on earth. He intends to exhibit at the exposition in 1900 a torpedo of his invention. He will himself direct its movements from New York, without a conducting wire, by simple electric transmission through the high regions of the atmosphere.

And when we have been entertained what will be the result for humanity, thus threatened with the worst catastrophes, at the mercy of an infernal operator endowed with fiendish, almost diabolical power?

The man who could make this discovery knows how to reassure us in this regard. Like all inventors of destructive machines, he claims that his instrument will make the governments which are inclined to create international conflagrations hesitate. The power of destruction of which he disposes is, he says, so unlimited and its employment in war would endow an army with such an instrument of victory, that no country being concerned about the lives of human beings would dare to assume before civilization, before history, the terrible responsibility of a scientific war. On whose quarrels will be settled in view of the terror of the cataclysms promised by science, views radiant with peace, which has at last conquered over centuries of barbarism, and there will be definite harmony in the entirely pacified universe!

What contradictions of conception is the human mind subject to? At the moment when, thanks to the magnanimous initiative of Czar Nicholas II, the problem of universal disarmament is attracting the attention, the solicitude, of the diplomats of all nations, an inventor, a physicist of the New World, promises us the end of the barbarous international duels by the tragical horror of the work of Death, by an unheard-of improvement in the processes of destruction.

Will the universal peace result, then, from the excess of evil, or from the moral philosophy which springs out of modern civilization? Who can predict it to a certainty?

What does it matter, after all, whether we owe it to the former or the latter, if only some day this sublime utopian dream, this dawn of new times announced by the prophets of humanity, will realize, perhaps, at the beginning of the century which is about to be born. MARCEL HUART.

Paris, November 12.

clusively in this journal on November 9 and 16. The following passage from the patent, in which the italics are our own, is republished as bearing on this question :

"It will be obviously noted from the preceding that, whichever of these or similar contrivances be used, the sensitiveness and, what is often still more important, the reliability of operation are very materially increased by a close adjustment of periods of vibration of the transmitting and receiving circuits, and, although such adjustment is in many cases unnecessary for the successful carrying out of my invention [Tesla evidently refers here to the [illegible] uses of his invention in peace—ED.] I nevertheless make it a rule to bestow on this feature the greatest possible care, not only because of the above-mentioned advantages, which are secured by the observance of the most favorable conditions in this respect, but also, and chiefly, with the [illegible] of *preventing the receiving circuit from being affected by waves or disturbances emanating from sources not under the control of the operator*. The narrower the range of vibrations, which are still capable of perceptibly affecting the receiving circuit, the safer will the latter be against extraneous disturbances. To secure the best result it is necessary, as is well known to experts, to construct the receiving circuit, or that part of the same in which the vibration chiefly occurs, so that it will have the highest possible self-induction and, at the same time, the least possible resistance. *In this manner I have demonstrated the practicability of providing a great number of such receiving circuits—50 or 100 or more—each of which may be called up or brought into action whenever desired without the other being interfered with.*"

The above statement answers part of the question to the point, for, if the sending and receiving circuits are skillfully adjusted, the enemy attacked would be practically powerless, as he could only by the barest chance strike the vibration to which the receiving circuit on the vessel would respond. It is difficult enough, even for the best expert, to make an exact adjustment of two such circuits, let alone the far more difficult problem which in this respect would confront the enemy attacked. Granted he had an apparatus on board capable of developing and such radiations may be screened off on the side towards the enemy, so that the latter could not affect the controlling device on the attacking vessel. Still, even in such an extreme case, it would seem to us that, while it might be easy to disturb the dot and dash signals in wireless telegraphy, it would be quite a different matter to prevent an operator from directing his vessel to wherever he desires, for *he* only would know precisely how the signals affect the mechanism, whereas the supposed opponent would have no knowledge whatever in this respect and could never tell whether, in working his apparatus, he is aiding or thwarting the efforts of his assailant. However, his signals would be of telling effect only after the assailing vessel had reached a point at which the signals from both the sources are of equal intensity. Now it would be quite easy, in our opinion, for the operator controlling the course of the vessel and the operation of the apparatus on board of the same, to direct it straight upon the enemy, put the machines at top speed, release the exploding mechanism and render all further signals inactive. Since the vessel can carry any amount of explosive, it would not be necessary to come very close to the enemy to insure his destruction.

How about the intensity of the signals? Can the signals from a man-of-war be made as strong as from a vessel especially fitted for this purpose? Would it be advisable to have such a powerful apparatus on board of a warship when the experts tell us that powerful electrical vibrations are apt to make large sparks fly about in any part of the structure, thus becoming liable to short-circuit the light mains and injure any of the important electrical apparatus on board, and, worst of all, inflame the stores of explosives? Would any commander undertake the responsibility of operating such a powerful apparatus on board of his ship under such conditions? Now it is not difficult to employ on shore a sending apparatus, fixed or portable, of great power, against which any on board of a warship would be ineffective, and we ask again how could a commander of a fleet possibly venture to approach the coast within 10 or 15 miles when he would know that in so doing he is risking not one but all of his vessels?

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Those who have criticized this important advance seem to confound a special means for carrying out the invention for the invention itself. The latter is not limited to any particular mode of signaling, and on this point Tesla expresses himself clearly, as may be seen from the following quotation :

"Finally, I may avail myself, in carrying out my invention, of electrical oscillations which do not follow any particular conducting path, but propagate in straight lines through space, of rays, waves, pulses, or disturbances of any kind, capable of bringing the mechanism of the moving body into action, from a distance and at the will of the operator, by their effect upon suitable controlling devices."

Signaling without wires, in some way or other, is very old—in fact, ancient—whereas Tesla, as we have before stated, has created an art entirely novel, for there never was such a thing as guiding the movements of a distant body and controlling all of its appliances without any artificial connection whatever.

It is, perhaps, astonishing that this epochal idea has not been evolved in times long past, for it would seem that it might have been carried into effect, without the use of any electrical means whatever, by some scientific observation that currents are propagated through the ground to considerable distances and that inductive effects take place between circuits widely apart, again enlarged the possibilities, until finally the science of electrical vibrations and synchronized circuits afforded the best means for carrying the idea into practice. These means, which are accessories in this invention, will, in all probability, multiply and be further improved as time goes on, and, with every advance in this direction, this new art will be brought to greater perfection.

To one who considers that for centuries past a large proportion of human effort has been spent in devising and producing the most efficient means for destroying an enemy, the tremendous importance of this new departure is instantly impressive. The weapon is no longer one dependent on the chance of hitting, nor one subject to the limitations of the modern projectile, nor one which can be rendered inoffensive by armor protection, however thick. The mere moral effect of a weapon of unlimited powers of destruction must be so great as to lead to a radical change in warfare, first on sea and next on land, but its success in the end can not help compelling the nations, for the sake of humanity, to stop the slaughtering of men and sacrifice of property.

Major Joseph H. Francis, who for many years had been connected with the New York Telephone Company and its predecessor, the Metropolitan Telephone and Telegraph Company, died at his home in Passaic, N. J., on November 28. Major Francis was well known among telephone people, having been engaged with several of the Bell licensee companies. While with the New York Telephone Company he was connected with the right of way department as agent. He had not been on active duty for some months, although he was an employé of the company up to the time of his death.

...SONAL.

...mith, of the Crocker-
...pany's Washington,
...ras in New York city

...Dean, of Lester, Dean
...hicago, dealers in rail-
... made a brief visit to
... last week.

... Harrison, of J. G.
...ny, New York city,
... treasurer of the
...w York.

... president of the
... Company, of Cleve-
...ts to return home
...bout April 1.

...s, the well known
... of Cleveland, Ohio,
...president of the re-
...seed oil trust.

...hnson, of the Man-
...d Supply Company,
... is enjoying a well
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...r, New York manager
... Company, has removed
...m 126 Liberty street to
...e Building at 95 Liberty

...rd F. Requa, general
...he Safety Insulated Wire
...ompany, of New York
...n enjoying a few days
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...falo, N. Y., Railway
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...pected to return to
... in May.

... Bryan, of Wash-
...ntil recently presi-

WESTINGHOUSE SUES GENERAL ELECTRIC ON THE TESLA PATENTS.

The following important information is received by the ELECTRICAL REVIEW just as it goes to press. It would indicate that some new features have entered into the big electric lighting deal in New York city. There is also a rumor that this is an entering wedge in the split that is said to be likely to come between the General Electric and Westinghouse interests in the matter of their patent agreement. The electrical field will view with much interest and concern this new move. The statement the ELECTRICAL REVIEW has received is as follows:

The suit referred to in your inquiry is doubtless the suit which the Westinghouse company has instituted in the Circuit Court of the United States for the Northern District of New York, to enjoin the General Electric Company from delivering multiphase apparatus covered by the Tesla patents to the Edison Electric Illuminating Company of New York. The suit is brought under the agreement relating to patents which the General Electric and Westinghouse companies entered into in March, 1896, and the Westinghouse company contends that the apparatus in question can not be delivered by the General Electric Company to the New York Edison company because of the exclusive license under the Tesla patents which the Westinghouse Company's licensee in New York city, the United Electric Light and Power Company, has held for many years. The bill was filed at Utica, Tuesday, March 21, and the motion for a preliminary injunction is returnable Tuesday, April 4.

Mr. Francis E. Drake, director of

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...rs—M. Georges Pel-
... *L'Eclairage Elec-*
...umulators having
... zinc-coated copper
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very largely in the manufacture of micanite, and the manufacture of this commodity should prove a remunerative adjunct to any company taking up mica mining on a large scale in India.

Suit on Tesla Patents.

In the United States Circuit Court at Philadelphia, on April 24, Judge McPherson heard argument in the equity suit of the Tesla Electric Company, of New York, against Gordon J. Scott and others, of Philadelphia, in which it is sought to have the defendants enjoined from the making of alleged infringements on the plaintiff's patented improvements in electro-magnetic motors.

Notes on Light—A Correction.

TO THE EDITOR OF ELECTRICAL REVIEW:

Through carelessness at my office the cut which was printed with Note LX was the wrong one and shows no vacuum regulator. I, therefore, have written this supplement to

sold by central stations to electric-railway systems, whose feeder circuits are supplied with direct current from substations of the lighting organization. The use of a differential galvanometer with a standard of moderate capacity permits accurate measurements to be made without sacrifice of a high degree of portability, and gives much better results than the common method of the indicating instrument and stop watch, which is best adapted to the measurement of steady loads. In the alternating-current field, the growing use of induction instruments is literally developing a new field of service in which with compactness of installation, is obtained a high degree of accuracy, high ratio of torque to weight, simplicity of structure and negligible external-field errors.

In the important field of current-transformer design, advanced methods of studying the phase angle and ratio are evidenced by the latest publications read at Boston, and a sensitivity of 1 in 10,000 at one-tenth load is now possible in apparatus of this type, when using a detector sensitive to about 2 microvolts. Improved methods of testing such transformers, in which but a single observer is required, without a polyphase source of voltage, phase-shifting device or rotating commutator, all point to the steady advance of the art of accurate measurement and to the progress of research into phenomena heretofore hidden or at least difficult of access. In the light of the Boston papers and discussions, the reputation of alternating-current instrumental work is certain to advance still further from the more or less doubtful status which it bore a few years ago.

WIRELESS TRANSMISSION.

Ever since the celebrated experiments of Heinrich Hertz, the possibility of radiating electric energy from an oscillator to a receiving apparatus was realized. At first it seemed as if the feebleness of such radiation would prevent its transmission to any considerable distance, but the persistent work of Marconi and other investigators showed that transmission to a considerable distance is quite possible by this method. With the further developments of the art it was found, however, that the practical results in wireless transmission did not entirely agree with the laws which were theoretically derived on the basis of the Hertz-wave theory.

Another phenomenon which has puzzled experimenters and practical operators in wireless telegraphy is the fact that the distance of transmission of wireless signals, which of course depends upon the rate of attenuation, depends upon atmospheric conditions, being much less in the daytime when the sun is shining upon it than at night time. The ionization effect of ultra-violet light is well known and the radiation of the sun is known to contain a considerable proportion of these important wave-lengths. There has been no satisfactory relation established, however, between the conditions of ionization and the strength of the received signals.

In an article which will be found upon pages 34 and 35 of this issue, Dr. Nikola Tesla has propounded a theory, which is supported by his experimental observations, to account for the practical results which have been observed. He has come to the conclusion that the Hertzian waves are responsible for but a small part of the energy which is transmitted from a wireless antenna, the main consideration in such transmission being conduction through the earth. Of course it is not maintained that signals cannot be and are not transmitted by Hertzian waves, as in some cases, notably in transmission to and from balloons and aeroplanes, earth currents are eliminated and dependence must be placed entirely upon radiation through the atmosphere. In most cases of long-distance signaling, however, earth connections are found essential to the best results and it cannot be doubted that the currents flowing into and out of the earth at the point of connection of the antenna or the auxiliary apparatus are important incidents in the operation.

Regarding the effect of sunlight upon transmission, Dr. Tesla presents a unique explanation which experts in this field would probably not be willing to accept without further demonstration. He attributes the change in facility of transmission to the evaporation of moisture from the earth's surface in places which are exposed to the sun's rays. Of course such evaporation is increased by the heat absorbed from the sun's radiation, a phenomenon which affects the conditions in the superficial layer of the earth's crust. Conduction through the earth could itself scarcely be effected in this way, but the explanation given by Dr. Tesla is that the evaporated particles of moisture carry off with them an electrical charge which affects the electrical distribution on the earth. He states that the dissipation of energy is proportional to the cube of the frequency, which would indicate that the best condition for transmission would be a low frequency and consequently large wave-length.

Dr. Tesla promises at some future time to contribute a more extensive discussion of this subject, disclosing the lengthy investigations which have led him to these important conclusions. The scientific and technical world will eagerly await a fuller demonstration of the truth of this theory.

range of delicate measurements of commercial value.

Again, the use of the Wheatstone-bridge—rotating-standard method of measuring large and rapidly fluctuating currents along the lines worked out by Professor H. A. Laws and Messrs. Ingalls and Cowles of Boston, marks a distinct advance which is of great value in such work as the measurement of energy sold by central stations to electric-railway systems, whose feeder circuits are supplied with direct current from substations of the lighting organization. The use of a differential galvanometer with a standard of moderate capacity permits accurate measurements to be made without sacrifice of a high degree of portability, and gives much better results than the common method of the indicating instrument and stop watch, which is best adapted to the measurement of steady loads. In the alternating-current field, the growing use of induction instruments is literally developing a new field of service in which with compactness of installation, is obtained a high degree of accuracy, high ratio of torque to weight, simplicity of structure and negligible external-field errors.

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tions and most notably upon the time of day; that is to say, whether the portion of the earth over which the signals are being transmitted is experiencing day or night.

There has been an attempt to connect the latter phenomenon with the state of ionization of the atmosphere, which is naturally assumed to be different when the sun is shining upon it than at night time. The ionization effect of ultra-violet light is well known and the radiation of the sun is known to contain a considerable proportion of these important wave-lengths. There has been no satisfactory relation established, however, between the conditions of ionization and the strength of the received signals.

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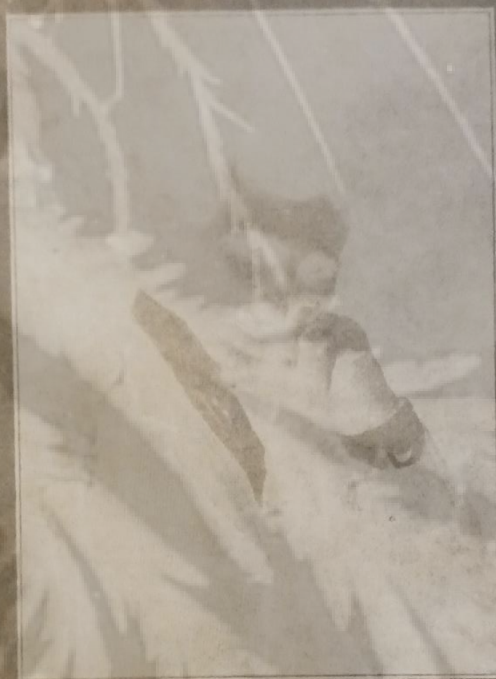
ject of this sketch.

Nikola Tesla was born at Smiljan, Lika, the border country of Austria-Hungary, in 1857, the son of a Greek clergyman and orator, and Georgina Mandic, who was an inventor, as was her father. Tesla was educated for a year in the elementary schools, for four years at the lower Realschule, Gospic, Lika, and for three years at the higher Realschule, Carlstadt, Croatia, graduating in 1878. He was a student for four years at Polytechnic School, Gratz, in mathematics, physics and mechanics. After this he studied two years in philosophic studies at the University of Prague, Bohemia. He has received the honorary degree of Master of Arts, from Yale, in 1904, and Columbia, N. Y., conferred the degree of LL.D. in 1894.

Nikola Tesla began his practical career at Budapest, Hungary, in 1881, where he made his first electrical invention, a telephone "repeater," and conceived the idea of his rotating magnetic field. He later engaged in various branches of engineering and manufacture, and, since 1884, has been a resident of the United States, becoming a naturalized citizen. Dr. Tesla is the author of numerous scientific papers and addresses, and his inventions and discoveries cover a wide range. Speaking chronologically, his chief work may be summed up as follows: systems of arc lighting, 1886; Tesla motor and system of alternating-current power transmission, 1888; system of electrical conversion and distribution by oscillating discharges, 1889; generation of high-frequency currents and effects of these, 1890; transmission of energy through a single wire without return, 1891; Tesla coil or transformer, 1891; investigations of high-frequency effects and phenomena, 1891-1893; system of wireless transmission of intelligence, 1893; mechanical oscillators and generators of electrical oscillations, 1894-1895; researches and discoveries in radiations, material streams, and emanations, 1895-1898; high-potential magnifying transmitter, 1897; system of transmission of power without wires, 1903. Since 1903, Dr. Tesla has been chiefly engaged in the development of his system of world telephony and telegraphy, and the design of a large plant for the transmission of power without wires. He has also devoted a great deal of energy to the development of a perfected system for the electrical production of nitrates from the



Nikola Tesla,
Noted Electrical Inventor and Scientist.

atmosphere and quite recently announced the development of a remarkable form of turbine, the perfecting of which when realized will mean practically a revolution in our application of mechanical principles. In the current issue of the ELECTRICAL REVIEW AND WESTERN ELECTRICIAN Dr. Tesla discusses with characteristic candor and vigor some new ideas with regard to the propagation of electrical impulses through the air without wires.

Water-Power Developments in Tennessee.

The Tennessee Eastern Electric Company is a new entrant in the hydroelectric field of Eastern Tennessee, following the Nolachucky River as the stream it is to develop, and will build a $500,000 plant six miles from Greeneville, Tenn. It has taken over the Greeneville Electric Company, and will use the plant there as a substation when the new plant is completed. It has also purchased control of the Watanga Power Company, and the Johnson City Traction Company, both of Johnson City, Tenn. It is reported that $500,000 was involved in this deal. The company has applied for franchises in Erwin, Jonesboro and Morristown, and plans not only to distribute electrical energy to those communities and others in the same section, but may also build an interurban traction system connecting the leading communities of Eastern Tennessee. The design and construction of the Nolachucky plant will be in charge of W. V. N. Powelson, of New York, former president and general manager of the Union Electric Light & Power Company, of St. Louis, who until recently has been consulting engineer with headquarters in New York. He will make his offices at Johnson City as soon as plans for the plant are made. Amzi Smith, general manager of the Johnson City properties, will continue to have charge of them. The company plans to generate 7,500 horsepower on Nolachucky River, and hopes to be furnishing power from there by April 1, 1913. The company was organized by Warner, Tucker & Co., of Boston, and represents New England capital almost exclusively, according to statements made in financial circles.

Officers of New England Section, Illuminating Engineering Society.

The following officers of the New England Section of the Illuminating Engineering Society have been elected for the coming year: chairman, R. B. Hussey; secretary, H. C. Jones; managers, H. C. Clifford, C. A. B. Halvorson, J. M. Riley, R. C. Ware, W. E. Wickenden. The address of the secretary is 10 High Street, Boston, Mass. Meetings are held in Boston.

Nikola Tesla.

In the realm of electricity and physics few men have striven for such mighty achievements and attained such prominence through the working out of ideas greatly in advance of current thought as has Nikola Tesla, the subject of this sketch.

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lowing the Tennessee Power Company which is developing water-power proj ects on the Ocoee River and Caney Fork, and the Tennessee Hydro-Elec tric Company, which is making use o the power possibilities of the Clinch and Powell Rivers. The Tennessee Eastern Electric Company has selected the Nolachucky River as the stream i is to develop, and will build a $500,000 plant six miles from Greeneville, Tenn It has taken over the Greeneville Elec tric Company, and will use the plant there as a substation when the new plant is completed. It has also purchased control of the Watauga Power Company and the Johnson City Trac tion Company, both of John son City, Tenn. It is report ed that $500,000 was involved in this deal. The company has applied for franchises in Erwin, Jonesboro and Mor ristown, and plans not only to distribute electrical energy to those communities and others in the same section but may also build an interurban traction system connecting the leading communities of Eastern Tennessee. The design and construction of the Nolachucky plant will be in charge of W. V. N. Powelson, of New York, former president and general manager of the Union Electric Light & Power Company, of St. Louis, who until recently has been consulting engineer with headquarters in New York. He will make his offices at Johnson City as soon as plans for the plant are made. Amzi Smith, general manager of the Johnson City properties, will continue to have charge of them. The company plans to generate 7,500 horsepower on Nolachucky River, and hopes to be furnishing power from there by April 1, 1913. The company was organized by Warner, Tucker & Co., of Boston, and represents New England capital almost exclusively, according to statements made in financial circles.

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Now, an error which should be the focus of investigation for experts is, that in the arrangement shown in Fig. 1 the Hertzian effect has been gradually reduced through the lowering of frequency, so as to be negligible when the usual wave-lengths are employed. That the energy is transmitted chiefly, if not wholly, by conduction can be demonstrated in a number of ways.

equal times over equal terrestrial areas. (See among others "Handbook of Wireless Telegraphy," by James Erskine-Murray.) Thus the velocity of propagation through the superficial layers is variable, dependent on the distance from the transmitter, the mean value being $\pi/2$ times the velocity of light, while the ideal flow along the axis of propagation takes place with a speed of approximately 300,000 kilometers per second.

To illustrate, the current from a transmitter situated at the Atlantic Coast will traverse that ocean—a distance of 4,800 kilometers—in less than 0.006 second with an average speed of 800,000 kilometers. If the signalling were done by Hertz waves the time required would be 0.016 second.

Bearing, then, in mind that the receiver is operated simply by currents conducted along the earth as through a

Fig. 3.—Illustrating Disturbing Effect of the Sun on Wireless Transmission.

One is to replace the vertical transmitting wire by a horizontal one of the same effective capacity, when it will be found that the action on the receiver is as before. Another evidence is afforded by quantitative measurement which proves that the energy received does not diminish with the square of the distance, as it should, since the Hertzian radiation propagates in a hemisphere. One more experiment in support of this view may be suggested. When transmission through the ground is prevented or impeded, as by severing the connection or otherwise, the receiver fails to respond, at least when the distance is considerable. The plain fact is that the Hertz waves emitted from the aerial are just as much of a loss of power as the short radiations of heat due to frictional waste in the wire. It has been contended that radiation and conduction might both be utilized in actuating the receiver, but this view is untenable in the light of my discovery of the wonderful law governing the movement of electricity through the globe, which may be conveniently expressed by the statement that the projections of the wave-lengths (measured along the surface) on the

wire, energy radiated playing no part, it will be at once evident that the weakening of the impulses could not be due to any changes in the air, making it turbid or conductive, but should be traced to an effect interfering with the transmission of the current through the superficial layers of the globe. The solar radiations are the primary cause, that is true, not those of light, but of heat. The loss of energy, I have found, is due to the evaporation of the water on that side of the earth which is turned toward the sun, the conducting particles carrying off more or less of the electrical charges imparted to the ground. This subject has been investigated by me for a number of years and on some future occasion I propose to dwell on it more extensively. At present it may be sufficient, for the guidance of experts, to state that the waste of energy is proportional to the product of the square of the electric density induced by the transmitter at the earth's surface and the frequency of the currents. Expressed in this manner it may not appear of very great practical significance. But remembering that the surface density increases with the frequency it may also be

using wave-lengths of 6,000 meters it is still noticeable though not a serious drawback. With wave-lengths of 12,000 meters it becomes quite insignificant and on this fortunate fact rests the future of wireless transmission of energy.

To assist investigation of this interesting and important subject, Fig. 3 has been added, showing the earth in the position of summer solstice with the transmitter just emerging from the shadow. Observation will bring out the fact that the weakening is not noticeable until the aerials have reached a position, with reference to the sun, in which the evaporation of the water is distinctly more rapid. The maximum will not be exactly when the angle of incidence of the sun's rays is greatest, but some time after. It is noteworthy that the experimenters who watched the effect of the recent eclipse, above referred to, have observed the delay.

Metal Mining in Missouri.

The value of the mine output of silver, copper, lead, and zinc in Missouri for the calendar year 1911, according to the United States Geological Survey, was $30,171,311, compared with $28,086,887 in 1910, an increase of over $2,000,000.

The production of silver amounted to 49,867 fine ounces, valued at $26,430, an increase of 16,771 ounces over 1910. The production of copper was 640,411 pounds, compared with 94,452 pounds in 1910. The quantity of lead concentrates produced increased from 248,058 to 258,240 short tons and the metal content of the lead concentrates increased from 161,016 to 178,868 tons. The low prices paid for zinc concentrate during the first 10 months of 1911 caused a decline in the production of zinc. The output of sphalerite was 217,812 short tons, compared with 232,341 tons in 1910. The production of zinc carbonate and zinc silicate concentrates was only 20,119 tons, which was less than in any previous year since 1907.

Electrification for Denver & Rio Grande.

Investigation is being made by engineers to determine the feasibility of electrifying the Denver & Rio Grande Railroad across the mountain passes of Colorado.

It is said that if electric current can be purchased for not more than 0.87 cent per kilowatt-hour the company will buy its power.

necessary, as a ground connection greatly reduces the intensity of the radiation by cutting off half of the oscillator and also by increasing the length of the waves from 40 to 100 per cent, according to the distribution of capacity and inductance. In the system devised by me a connection to earth, either directly or through a condenser, is essential. The receiver, in the first case, is affected only by rays transmitted through the air, conduction being excluded; in the latter instance there is no appreciable radiation and the receiver is energized by currents conducted through the earth while an equivalent electric displacement occurs in the atmosphere.

Now, an error which should be the focus of investigation for experts is, that in the arrangement shown in Fig. 1 the Hertzian effect has been gradually reduced through the lowering of frequency, so as to be negligible when the usual wave-lengths are employed. That the energy is transmitted chiefly, if not wholly, by conduction can be demonstrated in a number of ways.

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earth's diameter or axis of symmetry of movement are all equal. Since the surfaces of the zones so defined are the same the law can also be expressed by stating *that the current sweeps in equal times over equal terrestrial areas.* (See among others "Handbook of Wireless Telegraphy," by James Erskine-Murray.) Thus the velocity of propagation through the superficial layers is variable, dependent on the distance from the transmitter, the mean value being $\pi/2$ times the velocity of light, while the ideal flow along the axis of propagation takes place with a speed of approximately 300,000 kilometers per second.

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stated that the loss is proportional to the cube of the frequency. With waves 300 meters in length economic transmission of energy is out of the question, the loss being too great. When using wave-lengths of 6,000 meters it is still noticeable though not a serious drawback. With wave-lengths of 12,000 meters it becomes quite insignificant and on this fortunate fact rests the future of wireless transmission of energy.

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Metal Mining in Missouri.

The value of the mine output of silver, copper, lead, and zinc in Missouri for the calendar year 1911, according to the United States Geological Survey, was $30,171,311, compared with $28,086,887 in 1910, an increase of over $2,000,000.

The production of silver amounted to 49,867 fine ounces, valued at $26,430, an increase of 16,771 ounces over 1910. The production of copper was 640,411 pounds, compared with 94,452 pounds in 1910. The quantity of lead concentrates produced increased from 248,058 to 258,840 short tons and the metal content of the lead concentrates increased from 161,016 to 178,868 tons. The low prices paid for zinc concentrate during the first 10 months of 1911 caused a decline in the production of zinc. The output of sphalerite was 217,812 short tons, compared with 232,341 tons in 1910. The production of zinc carbonate and zinc silicate concentrates was only 20,119 tons, which was less than in any previous year since 1907.

Electrification for Denver & Rio

was an obstacle which could not be overcome by any improvement devised by man and of such nature as to fill me with apprehension that transmission of power without wires might never be quite practicable. I think it useful, in the present phase of development, to acquaint the profession with my investigations.

It is a well known fact that the action on a wireless receiver is appreciably weaker during the day than at night and this is attributed to the effect of sunlight on the elevated strata, an explanation naturally suggested through an early observation of Hertz. Another theory, ingenious but rather far-fetched, is that some of the energy of the waves is absorbed by ions or electrons, freed in sunlight and caused to move in the direction of propagation. The Electrical Review and Western Electrician of June 7, 1919, contains a report of a test, during the recent solar eclipse, between the station of the Royal Dock Yard in Copenhagen and the Blaavandshuk station on the coast of Jutland, in which it was demonstrated that the signals in that region became more distinct and reliable when the sunlight was partially cut off by the moon. The object of this communication is to show that in all the instances reported the weakening of the impulses was due to an entirely different cause.

It is indispensable to first expel a few errors under which electricians have labored for years, owing to the tremendous momentum imparted to the scientific mind through the work of Hertz which has hampered independent thought and experiment. To facilitate understanding, attention is called to the annexed diagrams in which Fig. 1 and Fig. 2 represent, respectively, the well known arrangements of circuits in the Hertz-wave system and my own. In the former the transmitting and receiving conductors are separated from the ground through spark gaps, choking coils and high resistances. This is

Fig. 1—Hertz Wave System.

this, the theoretical prospect was for a long time discouraging. I found that currents of high frequency and potential, such as had to be necessarily employed for the purpose, passed freely through air moderately rarefied. Judging from these experiences, the dielectric stratum separating the two conducting spherical surfaces could be scarcely more than 50 kilometers thick and, consequently, the capacity would

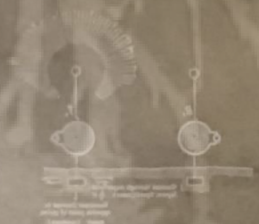


Fig. 2—System Devised By Tesla.

be over 220,000 microfarads, altogether too great to permit economic transmission of power to distances of commercial importance. Another observation was that these currents cause considerable loss of energy in the air around the wire. That such waste might also occur in the earth's atmosphere was but a logical inference.

A number of years passed in efforts to improve the apparatus and to study the electrical phenomena produced. Finally my labors were rewarded and the truth was positively established: the globe did not act like a conductor

demonstration of a concerted scientific idea surrounded the novel suggestion with a nimbus of originality and an atmosphere of potent achievement. I also caught the fire of enthusiasm but was not long deceived in regard to the practical possibilities of this method of conveying intelligence.

Granted even that all difficulties were successfully overcome, the field of application was manifestly circumscribed. Heliographic signals had been flashed to a distance of 200 miles, but to produce Hertzian rays of such penetrating power as those of light appeared next to impossible, the frequencies obtainable through electrical discharges being necessarily of a much lower order. The rectilinear propagation would limit the action on the receiver to the extent of the horizon and entail interference of obstacles in a straight line joining the stations. The transmission would be subject to the caprices of the air and, chief of all drawbacks, the intensity of disturbances of this character would rapidly diminish with the distance.

But a few tests with apparatus, far ahead of the art of that time, satisfied me that the solution lay in a different direction, and after a careful study of the problem I evolved a new plan which was fully described in my addresses before the Franklin Institute and National Electric Light Association in February and March, 1893. It was an extension of the transmission through a single wire without return, the practicability of which I had already demonstrated. If my ideas were rational, distance was of no consequence and energy could be conveyed from one to any other point of the globe, and in any desired amount. The task was begun under the inspiration of these great possibilities.

While scientific investigation had laid bare all the essential facts relating to Hertz-wave telegraphy, little knowledge was available bearing on the system proposed by me. The very

THE DISTURBING INFLUENCE OF SOLAR RADIATION ON THE WIRELESS TRANSMISSION OF ENERGY.

By Nikola Tesla.

When Heinrich Hertz announced the results of his famous experiments in confirmation of the Maxwellian electromagnetic theory of light, the scientific mind at once leaped to the conclusion that the newly discovered dark rays might be used as a means for transmitting intelligible messages through space. It was an obvious inference, for heliography, or signalling by beams of light, was a well recognized wireless art. There was no departure in principle, but the actual demonstration of a cherished scientific idea surrounded the novel suggestion with a nimbus of originality and atmosphere of potent achievement. I also caught the fire of enthusiasm but was not long deceived in regard to the practical possibilities of this method of conveying intelligence.

Granted even that all difficulties were successfully overcome, the field of application was manifestly circumscribed. Heliographic signals had been flashed to a distance of 200 miles, but to produce Hertzian rays of such penetrating power as those of light appeared next to impossible, the frequencies obtainable through electrical discharges being necessarily of a much lower order. The rectilinear propagation would limit the action on the receiver to the extent of the horizon and entail interference of obstacles in a straight line joining the stations. The transmission would be subject to the caprices of the air and, chief of all drawbacks, the intensity of disturbances of this character would rapidly diminish with the distance.

But a few tests with apparatus, far ahead of the art of that time, satisfied me that the solution lay in a different direction. The first requirement, of course, was the production of powerful electrical vibrations. To impart these to the earth in an efficient manner, to construct proper receiving apparatus, and develop other technical details could be confidently undertaken. But the all-important question was, how would the planet be affected by the oscillations impressed upon it? Would not the capacity of the terrestrial system, composed of the earth and its conducting envelope, be too great? As to

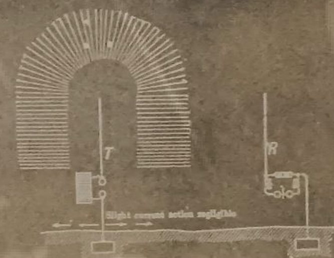
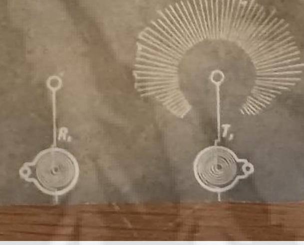


Fig. 1.—Hertz Wave System.

this, the theoretical prospect was for a long time discouraging. I found that currents of high frequency and potential, such as had to be necessarily employed for the purpose, passed freely through air moderately rarefied. Judging from these experiences, the dielectric stratum separating the two conducting spherical surfaces could be scarcely more than 20 kilometers thick and, consequently, the capacity would



of immense capacity and the loss
energy, due to absorption in the
was insignificant. The exact mode
propagation of the currents from
source and the laws governing
electrical movement had still to be
certained. Until this was accompli
the new art could not be placed on
plane of scientific engineering.
could bridge the greatest distanc
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limit to the intensity of the vibra
developed by such a transmitter,
the installment of economic plants
the predetermination of the effect
required in most practical applicat
would be impossible.

Such was the state of things in
when I discovered a new difficul
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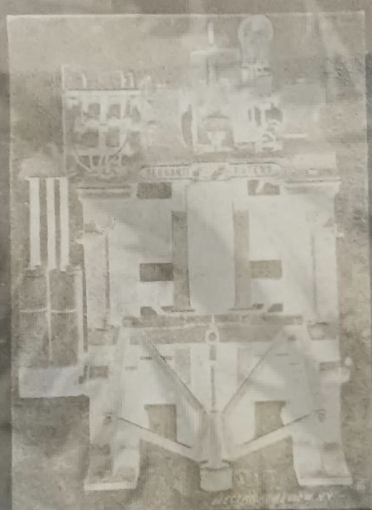
Tesla Lectures in Chicago.

Mr. Nikola Tesla was entertained by the Commercial Club, of Chicago, on May 13, and in the evening delivered an address before the club. Besides the members, many prominent scientists and educators attended the



Arc Lighting Rectifiers—The Ferranti Rectifier.

dinner in his honor, which was an elaborate affair. Mr. Tesla gave a number of interesting demonstrations,

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To the Editor of Electric

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ARC LIGHTING RECTIFIERS—BATTERY OF RECTIFIERS ...
(LONDON) STATION.

one of which was steering a boat from the shore, using a seven-foot model on a miniature lake, built in the banquet-hall for the occasion. His experiments did not begin until nearly midnight and lasted until a late hour.

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tric Company are able to turn out the best quality of apparatus economically, and the busy aspect apparent throughout the works is evidence of the appreciation of the company's products by their customers.

TESLA ON LONG LIFE AND SLEEP.

Being asked for his views on reasons and signs of longevity, Mr. Tesla said: "A man receives a certain term of life; so many hours to pass on this earth—I mean hours when he is alive, awake; I do not count the hours when he is sleeping; I do not believe they are, strictly speaking, included in his term of life. When a man really lives he is dying hour by hour, but when he sleeps he is accumulating vital forces which will make him go on living. In other words, in measuring out our dole of hours to each one of us, the great timekeeper stops his count while we are sleeping. Therefore, the longer a man sleeps the longer he will remain on earth. Nearly all long-lived people have been great sleepers. When De Lesseps was on the ocean he would sleep twenty hours on a stretch. Gladstone is a great sleeper, and averages twelve hours a day. I can believe that a man who would learn to sleep eighteen hours a day might live 200 years." Mr. Tesla is himself a very poor sleeper.

TELEPHONY

tect by electric mine and torpedo our whole coast line and harborage and do for the Government that which in this respect the U. S. Military Telegraph Corps did for it on land in other times of need. Here is genuine opportunity for youthful electrical patriotism, so far as the frontiers on the sea are concerned.

MR. TESLA AS A BUG KILLER.

THERE can be no doubt as to the invasion of the domain of agriculture by electricity. Last week we noted the results obtained on a farm in Germany, and hardly a week goes by without its news of farmers using the telephone in their operations, experiments at agricultural stations with all kinds of current in stimulating seeds and plants, or the use of power from lighting or trolley circuits in running farm machinery. Indeed, it may be said to be doubtful whether the factory or the farm is to be the new scene of electricity's next triumphs.

It will be remembered that not long ago, Mr. Tesla suggested that part of the energy of powers like that of Niagara might be applied to furnishing nitrogenous elements to the soil, so that better crops could be secured. This may explain why a Mr. S. S. Harvey in the South wrote to him asking if electricity could not be used in a general pervasive way to kill off the bugs that are such a pest in orchards and vineyards. Mr. Tesla, with wonted courtesy, admitted the importance of the subject and said in response to the inquiry: "It is sure that we can destroy these detrimental insects in certain ways by the help of electricity, but to what extent the trees would be affected by the application of these means I do not know, and it could only be settled by a series of experiments. I have some ideas on the subject, and think that an apparatus for experimentation could be produced in a short time. I am resolved to think over the matter in the hope to arrive at some tangible result."

We have no doubt that to some people the idea of a notable electrical inventor devoting his time to devising bug traps

and "sure deaths" smacks rather of the grotesque and ridiculous; but in reality Mr. Tesla could not undertake anything of more real and practical value. When one stops to consider how famine, ruin and devastation afflict the human race because of such pests as the locust, phylloxera, army worm and potato bug, it is evident there is work to do of real vital importance to a great many people.

ROENTGEN TUBE CONTROL.

THE enthusiasm with which the Röntgen ray has been taken up, especially in the United States, has led to the design of excellent apparatus for this work at a reasonable cost. It has thus placed in the hands of the scientist and surgeon a powerful instrument of research, and given the amateur a new and attractive instrument for his diversion. But, perfect as the mechanical and electrical part of such apparatus has been made, the weak spot in the combination is still the tube, which has to be constantly coaxed, as it were, to bring out the desired form of rays. The variability in the

The Electrical Engineer Feb. 3, 1897 pp. 140-141

MR. TESLA'S VIEWS ON THE FUTURE OF ELECTRICITY.

THE inauguration of the Buffalo-Niagara electric transmission, brought together, as our report showed, a representative gathering of influential men and elicited a number of memorable addresses. Of the speeches devoted to the technical side, that of Mr. Tesla's deserves more than passing notice, as containing the expression of his latest views and convictions on subjects which he has made his special study for some time past. Speaking of the types of prime movers in use to-day, Mr. Tesla gives no encouragement for the future of the reciprocating high speed engine in its present form, nor for the steam turbine. His ideal engine is one which expands the working fluid with utmost rapidity and loses little heat in the walls; an engine stripped of all usual regulating mechanism, packings, oilers and other appendages and forming part of an electric generator. Mr. Tesla, though not mentioning it by name, here evidently referred to his oscillator, brought out in 1893. As to the outlook for a carbon consuming battery, Mr. Tesla does not consider it over-promising, viewed from the standpoint of a source of power. The probability of replacing the engine-dynamos by batteries is, in Mr. Tesla's opinion, a remote one, the more so as the high pressure steam engine and the gas engine give promise of a considerably more economical conversion. Mr. Tesla also sees drawbacks lurking in the fact that carbon to be consumed in batteries has to be prepared for that purpose and cannot be used as found, as it is under the boiler. The manipulation, cleaning, renewal, regulation, etc., of the batteries, and their size, together with the character of the liquids employed in them, would make it difficult, if not unprofitable, to handle such a plant in a densely populated city district. While thus expressing little faith in the carbon battery, Mr. Tesla has hopes for the ultimate supply of isolated plants or dwellings in the development of what he calls a light "storage battery," involving the use of chemicals manufactured by cheap water power, such as some carbide or oxy-hydrogen cell. We incline to the opinion that what Mr. Tesla has in mind partakes more of the nature of a primary gas battery.

But it is Mr. Tesla's conclusions on the results of his own particular work which will perhaps command the greatest attention among electrical engineers and the public at large. It will be recalled that in his very first lecture at Columbia University in 1891 he threw out the suggestion that it might be possible to operate engines at any point on the earth "by the energy of the medium." Six years of continued study have brought him beyond the stage of mere conviction, and he now feels sure that the realization of his ideas is not far off. But at the same time Mr. Tesla confesses the disappointing conclusion reached by him that under the theoretically best conditions such a method of obtaining power cannot equal in economy, simplicity and many other features the present method of converting the energy of falling water into electric current, and transmitting it over long distances at high potential. With this conviction of the greater utility of water power, Mr. Tesla has bent his energies to the means of transmitting it, and now informs us that he has devised means which permit of power transmission at potentials much higher than are now considered practical. He hints further that the progress he has made gives him fresh hope that he will be able to transmit power from station to station without the em-

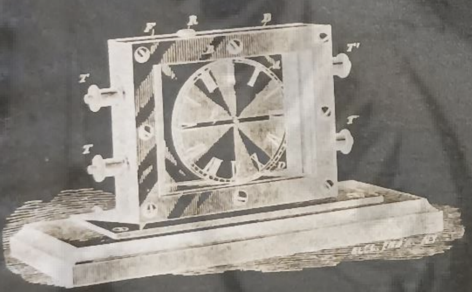
AN ELECTROLYTIC CLOCK.

BY

Nikola Tesla

If a delicately pivoted and well-balanced metal disc or cylinder be placed in a proper plating solution midway be- tween the anode and cathode, one half of the disc becomes electro positive and the other half electro negative. Owing to this fact metal is deposited on one, and taken off from the other half, and the disc is caused to rotate under the action of gravity. As the amount of metal deposited and taken off is proportionate to the current strength, the speed of rotation, if it be small, is proportionate to the current.

The first device of this kind was operated by me early in 1888, in the endeavor to construct an electric meter. Upon learning, however, that I had been anticipated by others, as far as the principle is concerned,[1] I devised the apparatus illustrated in the accompanying engraving. Here F is a rectangular frame of hard rubber which is fastened upon a wooden base. This frame is about ½ inch thick, 6 inches long and 5 inches high. On both of its upright sides are fastened thick metal plates which serve as the electrodes. These plates are held firmly against the rub- ber frame by the binding posts T T and T[1] T.[1] On the lateral sides of the frame are fastened the brass plates B and B,[1] respectivly, of the same shape as the rubber frame F. These brass plates serve to keep in place two plates of



TESLA'S ELECTROLYTIC CLOCK.

polished glass, and the vessel is hermetically sealed by placing a soft rubber washer under and above each of the glass plates. In this manner the plates may be screwed on tight without fear of breaking them.

The plating solution, which in this case is a concentrated solution of sulphate of copper, is poured in through an open- ing on the top of the rubber frame, which is closed by a plug R.

In the center of the vessel is placed a light and delicately balanced copper disc D, the axis of which is supported by a capillary glass tube which is fixed to one of the glass plates by means of sealing wax, or other material not attacked by the liquid. To diminish the friction as much as pos- sible, the capillary tube which serves as a bearing contains a drop of oil. The center of the disc should be equi-dis- tant from both the electrodes. To one side of the axis of the disc is fastened a very light indicator or pointer con- sisting preferably of a thin glass thread. The glass plate next to this pointer has a circle with the usual hour divis- sions engraved upon it, as on a clock dial. This circle may be movable so that it can be put in any position relatively to the [illegible] ... movable then a thin wire

should then be so placed that it is exactly in the centre of the solution. By means of a horse-shoe magnet the disc may then be rotated and set in proper position.

The copper solution being carefully poured in, and the plug R replaced, the terminals of a constant current bat- tery are connected to the binding-posts T T[1], and from time to time the rotation of the disc is observed. A shunt is connected to the other two binding-posts T T[1], and by vary- ing the resistance of this shunt, or other disc, the speed of rotation is regulated until it is made to correspond to the division of the dial; that is, until, for instance, one turn is made in 12 hours.

Obviously this instrument was not devised for a practi- cal purpose. Neither will it be quite exact in its indica- tions. There are certain errors, unavoidable from the principle; for instance, the friction, which cannot be com- pletely overcome. But the device is interesting as a means of indicating time in a novel manner. It will, however, be found that by a careful construction, constant cur- rent, and a temperature compensator, it may be made to rotate with almost perfect uniformity. The current den- sity should, of course, be very small to secure the best re- sults, and the disc of about 3 inches diameter should turn once in 6 hours. It is probable that with a silver solution and a silver plate better results would be obtained.

It is very interesting to note the appearance of the solu- tion and disc in such a narrow transparent vessel. The solution appears a clear blue, one side of the disc seems to be silver white in a certain position, and the other half is dark like tarnished silver. There is no line of demarca- tion, but the shades melt beautifully together.

OPERATING SUB-STATIONS BY THE MOTOR-DYNAMO SYSTEM IN BROOKLYN.

BY

W. S. Barstow

THE Edison Electric Illuminating Company of Brooklyn, during the fall of 1890, resolved to extend their territory for furnishing low tension light and power, by the erection of a second district station. After a careful consideration of the matter, it was deemed best to supply this new terri- tory from their present first district station until a suf- ficient load was accumulated to warrant the expenditure necessary for the erection and maintenance of the second district station. For this purpose a large feeder, consisting of copper conductors of 1,000,000 circ. mils each was laid underground to a point two miles distant from the present first district station. From this point sub-feeders were laid, and these in turn were heavily bridged by the net-work of mains. A standard feeder is selected from one of these sub-feeders, and at the extremity of this the voltage is kept at a constant pressure. As the load in- creases, the voltage is necessarily raised at the station end of the large feeder so as to preserve the voltage at the ex- tremity of the sub-feeder. The efficiency of this system of low tension long distance transmission depends on the cost of the loss in the main feeder compared with the in- creased operating expenses of a second district station. When the cost of the loss (in watts) in this transmission equals the operating expenses of a second district plant, then this plant will be erected and will be run until the cost of operating exceeds the loss in transmitting from the first district station. It has been theoretically calculated (and since proved by practical results) that 1,000 amperes can be transmitted before the starting of the new station is

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VOL. XI. NEW YORK, MAY 27, 1891. No. 160.

Many valuable inventions have been founded on the discovery of simple facts, but such inventions can never be perfected unless the principles of science upon which they are based are known.—Joseph Henry.

THE TESLA EXPERIMENTS.

WHILE the interest in all the papers of the annual meeting of the American Institute of Electrical Engineers was sustained throughout the sessions, there can be no question that most interest centred upon the lecture delivered by Mr. Tesla on the phenomena of alternating currents of high frequency. Mr. Tesla's recent utterances on this subject had served to excite the curiosity of many, and we believe that a thorough analysis of the work accomplished by Mr. Tesla, as exhibited in the experiments shown by him, will lead to the conclusion that those expectations have been more than realized. The brilliant researches and experiments inaugurated by Dr. Hertz, and followed up by Lodge and others, which served to verify the theory that the phenomena of light were referable to electromagnetic vibrations of the ether, seemed to point out an apparently easy way of obtaining illumination directly through the medium of electro-magnetic vibrations. It has remained for Mr. Tesla, however, to recognize that for the production of light, electrostatic effects are needed. He reasoned that it was impossible to obtain primarily the desired electro-magnetic effects, since we must work with bodies of infinitesimal dimensions which can be acted upon only electrostatically, it being evident that an electromagnetic wave cannot excite luminous radiation unless it be a true light wave. To produce longer electro-magnetic waves would, therefore, be of no avail; but this is not the case with electrostatic waves or thrusts. These, no mat-

omic charges, causing the molecules or atoms to vibrate and to emit light; and since electrostatic effects are dependent upon the conjoint effects of potential and frequency, this reasoning led him to the investigations, the results of which were shown.

Continuing the train of reasoning followed by Mr. Tesla, we see that he has recognized further, that electrostatic effects of such character are available in many ways for the production of light. Thus he showed that if a filament in a globe be connected with only a single terminal of the source, in consequence of the rapidly alternating potential, the molecules of the gas are strongly attracted and repelled, and in this manner by their impact a filament may be kept at incandescence with only one wire. With these facts before him, and recognizing further that the employment of a filament is a bar to the attainment of higher efficiency on account of the limited degree of incandescence at which it can be run, Mr. Tesla reasoned that two blocks of a refractory material may be placed in a perfectly exhausted globe and sufficient energy transferred by condenser action to keep the blocks at incandescence, thus allowing a much higher efficiency in the production of light by reason of the possibility thus afforded of maintaining the carbons at a much higher degree of incandescence. Mr. Tesla has also shown that it is perfectly practicable to transfer sufficient energy to the medium, from a single block or filament placed in a perfectly exhausted globe and connected with one wire to the source, to keep the filament at the desired incandescence. Another and most important fact which he demonstrated was the practicability of using tubes of rarified gas without any terminals as practical sources of illumination by simply creating an electrostatic field near them, and also of using lamps without leading-in wires. All these results can evidently only be obtained by the use of enormous frequencies and potentials, or, in other words, powerful electrostatic effects, the study of which was made difficult in consequence of the fact that in previous experiments, looking to this end, the static effects were excessively small, owing to the fact that the coil was short-circuited through the low resistance discharge between the knobs of the discharger. The method of conversion devised by Mr. Tesla, allowing of the use of any frequency, enables us to undertake a much more exact and easy study of the effects of short waves. Again, his experiments with the lamps burning when connected with their terminals to a short, thick copper bar, are extremely interesting. The possibility of verifying nodes on the bar by simply using a Cardew voltmeter will be of great value in investigating these phenomena. His experiments also prove that while, with alternating currents of low frequency, such as are now generally employed, the effects of self-induction must be largely considered, those of high frequency accentuate largely the condenser effects which have to be allowed for accordingly.

It would lead us too far to enter into all of the numerous points suggested by Mr. Tesla's lecture, but he showed enough to warrant the assertion that in a comparatively short time the practical application of these principles to the production of artificial illumination will be an accomplished fact.

TESLA'S EXPERIMENTS WITH ALTERNATING CURRENTS OF HIGH FREQUENCY.

THE Wednesday evening session of the American Institute of Electrical Engineers was held in Prof. Dwight's room, Columbia College, and will long be remembered by those present, not only on account of the brilliant experiments shown, but also for the many possibilities which it suggested in the development of the artificial illumination of the future. For the purpose of his experiments, Mr. Tesla employed the alternating machine with 384 poles, described in THE ELECTRICAL ENGINEER of March 18, 1891, which, when run at full speed, permitted him to obtain 20,000 alternations per second. The currents of this machine in all of Mr. Tesla's experiments were first run through a condenser in order to avoid the possibility of injury to the machine. The machine itself was set up in the electrical workshop of the college and was driven by an electric motor, the speed of which could be varied by a switch on the lecture platform.

Mr. Tesla introduced his subject by the remark that modern science has been able to make rapid strides by the recognition of ether as the medium of transmission of vibrations of various forms which manifest themselves to our senses. We are therefore now able to see things in a different light than was formerly the case, and, being tolerably well able to explain them, the truth cannot be hidden much longer. The answer to the question, "What is Electricity?" we were not yet prepared to give. We were justified in assuming, however, that electric phenomena are ether phenomena, and we may consider the phenomena of static electricity as phenomena of ether under strain, and those of dynamic electricity and electro-magnetism as phenomena of ether in motion.

Mr. Tesla, while expressing the highest consideration for the work of Dr. Lodge, was not in entire accord with the views advanced by him, which he considered to be more of the nature of ingenious explanations than of a probable theory, Mr. Tesla contending that there can be no two electricities.

Alluding further to the electro-magnetic theory of light, and to the Hertz experiments and those of Dr. Lodge and their application to the production of an efficient source of light, Mr. Tesla considered the electro-magnetic waves as unavailable for the production of luminous effects, for the reason that long before we could reach the necessary frequency the conductor would become opaque to the passage of the waves. Mr. Tesla thought that electro-magnetic waves, unless they have the frequency of true light waves, cannot produce luminous effects, Not so, however, with the electrostatic waves or thrusts. These, no matter what their frequency, can excite luminous radiation. He reasoned that the static effects in the Hertz and Lodge experiments were excessively small, due to the fact that they were produced in a practically closed coil, the spark acting as a bridge, making the coil practically continuous and depressing the potential. To obtain the desired difference of potential we must work with an open circuit generator of high potential of high frequency to enhance the electrostatic effects, and it was the recognition of this fact which led Mr. Tesla to the results he showed.

In carrying out this idea of obtaining enormous differences of potential, Mr. Tesla at once encountered the difficulty of obtaining the requisite insulation for the induction coil employed by him. His experience demonstrated that what we consider the best insulators, such as glass and rubber are inferior to others, not formerly so considered, such as oil and wax. Mr. Tesla then started a spark coil in action, the primary of which was in connection with his alternator which was speeded to give from 10,000 to 11,000 alternations per second. The coil emitted a clear note, which rose as the number of alternations was increased. As the discharges took place between the terminals of the coil, an exhausted Geissler tube held in proximity to the discharge did not light, but upon blowing out the arc the tube lighted up, which was due to the rise of potential caused by the rupture of the arc. This effec Mr. Tesla considered as purely electrostatic.

Mr. Tesla then showed the influence of insulated bodies having considerable size upon the spark length, demonstrating the effect of capacity upon the nature of the discharge. Thus when we attach an insulated body to the terminal of the coil, the potential may be raised or lowered. He showed this by wrapping an insulated wire of about one foot in length about one terminal of the coil, and touching the other terminal with a brass sphere held in the hand; under these conditions streams of light emanated from all sides of the wire. When the sphere was removed, however, the streams disappeared almost entirely. He then cut off the wire in successive lengths, and the stream discharges became more marked and brilliant. He then attached a fine platinum wire to the terminal, which also showed the streams to a remarkable degree, and kept up a continuous vibration to and fro. He also showed a pinwheel effect, the wheel being rapidly rotated with streams issuing from the two points. Another experiment consisted in attaching two spheres of about four inches diameter to

tops, is extinguished and is re-established at the first point, this being continuously repeated. The neighboring exhausted tubes and lamps were illuminated and extinguished in unison with the action of the spark between the spheres. These Mr. Tesla pointed out were not electro-magnetic vibrations like the Hertz waves. He showed how by the use of the dielectric the spark is induced to jump between the separated spheres, due to the increase in the specific inductive capacity of the medium, and he also demonstrated that the streaming discharge passed easily through thick glass plates, rubber plates and a book. Mr. Tesla then showed these static effects in a non-striking vacuum. A tube of this nature when connected to the machine glowed brightly, and the terminals became incandescent. Mr. Tesla then remarked that if, instead of using a filament in a lamp—which necessarily limited us in the degree of incandescence which we could practically employ,—we could employ solid blocks of carbon, much higher efficiency could be obtained. Based upon this reasoning, he had constructed a lamp which he showed, containing two blocks of carbon in a non-striking vacuum. When connecting these two carbons to the two terminals of the coil or one to one terminal and the other to a body of some size, the blocks can be raised to high incandescence.

Mr. Tesla also showed a lamp with but a single rod filament in a non-striking vacuum with no outward connection. The energy is entirely transferred by condenser action through the medium of condenser coatings in the base of the lamp. He also pointed out how the brilliancy of the lamp could be varied by simply altering the relative positions of the condenser coatings. This Mr. Tesla followed by demonstration of the phenomena with an unexhausted globe, and a single filament mounted therein. The filament when connected to one terminal of the coil heats up to bright incandescence and spins around in the globe. He also demonstrated the heating by the use of Crookes' well-known apparatus consisting of mica vanes mounted above a platinum wire, which was brought to incandescence by connection with one terminal of the coil, and rotated the mica vanes.

In order to still further verify the conclusions that the electrostatic effects are alone active, Mr. Tesla placed a Geissler tube at right angles to the coil and at its centre. In this position the tube did not light up. When placed at the ends, however, the tube lit up brilliantly and gave sufficient light to read by. Mr. Tesla showed both uranium and yttria tubes.

He then showed how exhausted tubes could be made to glow in an electrostatic field. For this purpose two large sheets of zinc were connected to the terminals of the machine at a distance of about 15 feet apart. The tube when placed between these sheets glowed brilliantly and could be moved about freely. Mr. Tesla remarked that, by merely creating such a field in a room, the mere suspension of the tubes in the room would afford the desired illumination.

Coming to the physiological effects, Mr. Tesla adjusted the conditions so that by touching one terminal with a brass sphere he raised the potential of the coil so enormously that a stream of light came out on the other terminal, and he estimated the difference of potential to be nearly 250,000 volts, and then performed the remarkable experiment of receiving the total discharge through his body, protecting his hands from burning by the brass balls held in his hands.

He then lit up lamps by holding them in contact with one terminal or near to the coil.

The lecturer then came to another class of experiments. He stated that he had used a system of conversion from high tension to low with the enormous frequencies of the condenser discharges. Mr. Tesla then showed an interesting experiment which consisted in passing the converted currents, produced in the manner just described, through a copper bar $\frac{3}{8}$ inch in diameter and bent into a loop. Ordinarily such a bar would constitute a short circuit, but Mr. Tesla succeeded in bringing lamps stretched across the parallel sides of the bar to incandescence, demonstrating that the impedance in the loop connecting the two sides was so great as to practically prevent the current from passing through it and hence acting upon the lamps in the manner described. He also pointed out the existence of modes on the bar. His method consists in continuously charging and disruptively discharging a condenser into the working circuit, the charging of the condenser being effected by a coil operated either by alternating or direct currents. By this means any desired higher frequency may be obtained from any lower frequency.

Mr. Tesla concluded his experiments by exhibiting in action a simple alternate current arc lamp, operated by currents direct from the machine giving 20,000 alternations per second. The light was beautifully steady and the arc entirely free from the hum accompanying arcs operated with currents of low frequency.

We have given but the merest outline of the many beautiful and highly suggestive experiments made by Mr. Tesla. Notwithstanding the fact that Mr. Tesla excited the intensest interest of his audience for three hours, he was nevertheless unable, for lack of time, to bring before them many experiments, some of which, brought

THE PHYSIOLOGICAL AND OTHER EFFECTS OF HIGH FREQUENCY CURRENTS.

BY

Nikola Tesla

IN THE ELECTRICAL ENGINEER of January 25, 1893, I note an article by Mr. A. A. C. Swinton, referring to my experiments with high frequency currents. Mr. Swinton uses in these experiments the method of converting described by me in my paper before the American Institute of Electrical Engineers, in May, 1891, and published in THE ELECTRICAL ENGINEER of July 8, 1891, which has since been employed by a number of experimenters; but it has somewhat surprised me to observe that he makes use of an ordinary vibrating contact-breaker, whereas he could have employed the much simpler method of converting continuous currents into alternating currents of any frequency which was shown by me two years ago. This method does not involve the employment of any moving parts, and allows the experimenter to vary the frequency at will by simple adjustments. I had thought that most electricians were at present familiar with this mode of conversion which possesses many beautiful features.

The effects observed by Mr. Swinton are not new to me and they might have been anticipated by those who have carefully read what I have written on the subject. But I cannot agree with some of the views expressed by him.

First of all, in regard to the physiological effects. I have made a clear statement at the beginning of my published studies, and my continued experience with these currents has only further strengthened me in the opinion then expressed. I stated in my paper, before mentioned, that it is an undeniable fact that currents of very high frequency are less injurious than the low frequency currents, but I have also taken care to prevent the idea from gaining ground that these currents are absolutely harmless, as will be evident from the following quotation: "If received directly from a machine or from a secondary of low resistance, they (high frequency currents) produce more or less powerful effects, and may cause serious injury, especially when used in conjunction with condensers." This refers to currents of ordinary potential differences such as are used in general commercial practice.

As regards the currents of very high potential differences, which were employed in my experiments, I have never considered the current's *strength*, but the *energy* which the human body was capable of receiving without injury, and I have expressed this quite clearly on more than one occasion. For instance, I stated that "the higher the frequency the greater the amount of electrical energy which may be passed through the body without serious discomfort." And on another occasion when a high tension coil was short-circuited though the body of the experimenter I stated that the immunity was due to the fact that less *energy* was available externally to the coil when the experimenter's body joined the terminals. This is practically what Mr. Swinton expresses in another way; namely, by saying that with "high frequency currents it is possible to obtain effects with exceedingly small currents," etc.

In regard to the experiments with lamp filaments, I have, I believe, expressed myself with equal clearness. I have pointed out some phenomena of impedance which at that time (1891) were considered very striking, and I have also pointed out the great importance of the rarefied gas surrounding the filament when we have to deal with currents of such high frequency. The heating of the filament by a comparatively small current is not, as Mr. Swinton thinks, due to its impedance or increased ohmic resistance, but principally to the presence of rarefied gas in the bulb. Ample evidence of the truth of this can be obtained in very many experiments, and to cite them would be merely lengthening this communication unduly.

Likewise, observations made when the experimenter's body was included in the path of the discharge, are, in my opinion, not impedance, but capacity, phenomena. The spark between the hands is the shorter, the larger the surface of the body, and no spark whatever would be obtained if the surface of the body were sufficiently large.

I would here point out that one is apt to fall into the error of supposing that the spark which is produced between two points on a conductor, not very distant from each other, is due to the impedance of the conductor. This is certainly the case when the current is of considerable strength, as for instance when, like in the Faraday experiment or some of Dr. Lodge's, a heavily-charged

battery of Leyden jars is discharged through a bent wire. But, when there is a vibration along a wire which is constantly maintained, and the current is inappreciable whereas the potential at the coil terminal is exceedingly high, then lateral dissipation comes into play prominently. There is then, owing to this dissipation, a rapid fall of potential along the wire and high potential differences may exist between points only a short distance apart. This is of course not to be confounded with those differences of potential observed between points when there are fixed waves with ventral and nodal points maintained on a conductor. The lateral dissipation, and not the skin effect, is, I think, the reason why so great an amount of energy may be passed into the body of a person without causing discomfort.

It always affords me great pleasure to note, that something which I have suggested is being employed for some instructive or practical purpose; but I may be pardoned for mentioning that other observations made by Mr. Swinton, and by other experimenters, have recently been brought forward as novel, and arrangements of apparatus which I have suggested have been used repeatedly by some who apparently are in complete ignorance of what I have done in this direction.

ELECTRICAL RECORDING METERS.—II.

BY CARYL D. HASKINS.

There is another device, or perhaps I had better say there might be another device for accomplishing the object of this last meter in a somewhat similar manner. The actinometer is probably

sons practically acquainted with them are especially desired. Unavailable
rejected manuscripts will be returned only when accompanied by the neces
postage.

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other columns only such matter as we consider of interest or value to our reader

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MR. TESLA'S HIGH FREQUENCY WORK.

IT is now nearly a year since Mr. Nikola Tesla, after
brilliant demonstrations here, scored such decided
umphs in the lectures which he delivered abroad at the i
tation of various scientific societies; yet the interest wh
is manifested in his recent work not only by electricians
by many laymen, is such as to make highly welcome
publication of the abstract of Mr. Tesla's lecture, prepa
by him for, and just published in, the Transactions of
Royal Institution of England. In this abstract, Mr. T
gives a succinct account of the reasonings and experime
which led up to the results obtained by him, and, ta
altogether, they present a remarkable array of experime
facts in a field entirely new. Although replete with f
and suggestions, many of them quite new, it must be
dent that the paper embodies but a tithe of Mr. Te
work in this field, the complete record of which would
more than one volume of surpassing interest. Those
attend the convention of the National Electric Light Ass
ation in St. Louis, next month, will have an opportunit
witnessing some of Mr. Tesla's experiments in a lec
which he has consented to deliver before the Associat

EMANCIPATING THE CANAL MULE.

IN his message to the Legislature, Governor Flowe
New York, remarks that only steam canal-boats capab

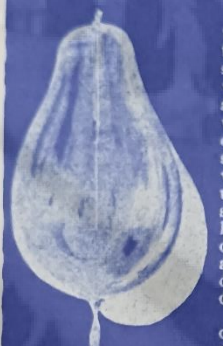
"You mean Mr. Pender," he answered, with the faintest perceptible smile.

"Yes," I replied, "and in the course of an hour's chat with him he spoke about you."

"Mr. Gould became at once interest ed, and said: "W ell, what did he say?" I repeated the words above quoted. He looked in at the tomb of Lawrence of "never give up the ship" fame just inside the church railings. Two o'clock in the afternoon; Broadway was thronged. Looking up suddenly, he saw that fifteen or twenty people had stopped to look at him. His pallid face flushed a little, and he said: "Will you walk down to the office with me?" It was only a few steps away. I then told him about the Wolseley incident, and what Mr. Pender had said of Western Union, which seemed to gratify him very much."

ALTERNATE CURRENTS OF HIGH POTENTIAL AND HIGH FREQUENCY.[1]—I.

BY NIKOLA TESLA.



AT the first outset this investigation was taken up with the view of studying the effects of rapidly changing electrostatic and electromagnetic stresses. It was thought, from theoretical considerations, that some useful observations would be made in following up this line of experiment by means of properly constructed apparatus; but the anticipations were by far surpassed, for a number of unexpected phenomena were noted, and some novel facts brought to light, which have opened up a new and promising field of research. Some of the results obtained are of special interest on account of their direct bearing upon the problem of producing an efficient illuminant.

The phenomena which are due to the changing character of the stresses are exalted when the time rate of change is increased, hence the study of these phenomena is much facilitated by the employment of apparatus adapted especially for the purpose of carrying on such investigations. With this object in view, several types of alternators were constructed, capable of giving currents of frequencies from 5 to 10,000 and even more. Currents of much higher frequencies used in some of these experiments, were obtained by disruptively discharging condensers.

The construction of the alternators offered at first great difficulties. To obtain these frequencies it was necessary to provide several hundred polar projections, which were necessarily small and offered many drawbacks, and this the more, as exceedingly high peripheral speeds had to be resorted to. In some of the first machines both armature and field had polar projections. These machines produced a curious noise, especially when the armature was started from the state of rest, the field being charged. The most efficient machine was found to be one with a drum armature, the iron body of which consisted of very thin wire annealed with special care. It was, of course, desirable to avoid the employment of iron in the armature, and several machines of this kind, with moving or stationary conductors were constructed, but the results obtained were not quite satisfactory, on account of the great mechanical and other difficulties encountered.

The study of the properties of the high frequency currents obtained from these machines is very interesting, as nearly every experiment discloses something new. Two coils traversed by such a current attract or repel each other with a force which, owing to the imperfection of our sense of touch, seems continuous. An observation, scarcely foreseen, is that a piece of iron, surrounded by a coil through which the current is passing appears to be continuously magnetized. This apparent continuity might be ascribed to the deficiency of the sense of touch, but there is evidence that in currents of such high frequencies one of the impulses preponderates over the other. As might be expected, conductors traversed by such currents are rapidly heated, owing to the increase of the resistance, and the heating effects are relatively much greater in the iron.

The hysteresis losses in iron are so great that an iron core, even if finely subdivided, is heated in an incredibly short time. To give an idea, an ordinary iron wire of $\frac{1}{16}$ inch in diameter inserted within a coil having 250 turns, with a current estimated to be five

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1. A lecture delivered before The Royal Institution of Great Britain, Thursday, February 4, 1892. Author's abstract in Transactions.

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The Cataract Construction Company has already sunk a shaft sufficient to accomodate three of the 5,000 h. p. turbines which are to be used for the work of distributing light and power. Considerable difficulty was met with in sinking this shaft, by the influx of water through a seam at a depth of about 30 feet below the surface. These difficulties have never interfered with the progress of the work, which has now been successfully carried out. The turbines which are to be used are of 5,000 h. p., revolving at 250 revolutions per minute, of the Girard or impulse type, with a regulator for adjusting the flow of water. Each turbine is double. Attached to the shafts of the turbines are vertical shafts, extending to the surface of the ground, and, on the top of these shafts, the dynamos are to be mounted, which will transmit electricity, for light and power purposes, to the surrounding districts and to Buffalo. The turbines are from the designs of Messrs. Faesch and Piccard, of Geneva, who transmitted the working drawings to America; and the contract for these turbines has now been given out to the I. P. Morris Company, of Philadelphia, two turbines having been ordered in the first instance. Twenty of these will be required to utilize the full capacity of the tunnel, which is 100,000 h. p. (See diagram on page 64.)

ALTERNATE CURRENTS OF HIGH POTENTIAL AND HIGH FREQUENCY.—II.

BY NIKOLA TESLA.

In operating an induction coil with these rapidly alternating currents, it is astonishing to note, for the first time, the great importance of the relation of capacity, self-induction, and frequency as regards the general result. The combination of these elements produces many curious effects. For instance, two metal plates are connected to the terminals and set at a small distance, so that an arc is formed between them. This arc *prevents* a strong current to flow through the coil. If the arc be interrupted by the interposition of a glass plate, the capacity of the condenser obtained counteracts the self-induction, and a stronger current is made to pass. The effects of capacity are the most striking, for in these experiments, since the self-induction, and frequency both are high, the critical capacity is very small, and need be but slightly varied to produce a very considerable change. The experimenter brings his body in contact with the terminals of the secondary of the coil, or attaches to one or both terminals insulated bodies of very small bulk, such as exhausted bulbs, and he produces a considerable rise or fall of potential on the secondary, and greatly affects the flow of the current through the primary coil.

In many of the phenomena observed, the presence of the air, or, generally speaking, of a medium of a gaseous nature (using this term not to imply specific properties, but as contradistinction to homogeneity or perfect continuity) plays an important part, as it allows energy to be dissipated by molecular impact or bombardment. The action is thus explained :—

When an insulated body connected to a terminal of the coil is suddenly charged to a high potential, it acts inductively upon the surrounding air, or whatever gaseous medium there might be. The molecules or atoms which are near it are, of course, more attracted, and move through a greater distance than the further ones. When the nearest molecules strike the body they are repelled, and collisions occur at all distances within the inductive distances. It is now clear that, if the potential be steady, but little loss of energy can be caused in this way, for the molecules which are nearest to the body having had an additional charge imparted to them by contact, and not attracted until they have parted, if not with all, at least with most of the additional charge, which can be accomplished only after a great many collisions. This is inferred from the fact that with a steady potential there is but little loss in dry air. When the potential, instead of being steady, is alternating, the conditions are entirely different. In this case a rhythmical bombardment occurs, no matter whether the molecules after coming in contact with the body lose the imparted charge or not, and, what is more, if the charge is not lost, the impacts are only the more violent. Still, if the frequency of

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EXPERIMENTS WITH HIGH FREQUENCY ELECTRIC DISCHARGES.

BY

A. A. C. Swinton

THE author has succeeded in passing through his body from hand to hand sufficient electricity to bring the filament of an ordinary 5 c. p. 100 volt incandescent lamp very nearly to full incandescence, or to bring the filament of a 32 c. p. 100 volt lamp to full redness. Practically no sensation was experienced.

The apparatus employed consisted of a large "Apps" induction coil capable of giving 10″ sparks, supplied with current through the ordinary vibrating contact breaker and a resistance consisting of eight 50 c. p. lamps in parallel, from a 105 volt continuous current supply. To the positive and negative terminals of the secondary of the induction coil were connected respectively the inside and outside coatings of three half-gallon Leyden jars, connected in parallel. The disruptive discharge of these jars across an air gap of about a quarter of an inch excited the primary of a simple form of high frequency coil similar to those employed by Mr. Tesla and Prof. Elihu Thomson. The secondary of this coil consisted of 500 turns of No. 26 S. W. G. cotton covered wire wound on a paper tube. Outside this paper tube was a glass tube, upon which the primary, consisting of 10 turns of three No. 16 gutta percha covered wires, in parallel, were wound. The whole coil was immersed in resin oil contained in a wooden trough. The ends of the secondary were connected through small glass tubes, also filled with oil, to brass balls.

On approaching the hand to one of the balls forming the terminals of the oil coil, sparks shoot out from the brush discharge which surrounds it. If the spark is taken on the skin a sharp prick is felt, but on approaching the terminal or touching it with a piece of metal grasped in the hand, or after grasping the terminal itself, practically no appreciable sensation is felt. If the terminal is grasped in this manner with the right hand, sparks will shoot out from the left hand or indeed from any portion of the body, if brought into proximity with another person, a piece of metal, the gas or water pipes or any conducting body. In the experiment referred to, the incandescent lamp was hung by one terminal on a wire connected to earth and connection was made between the other lamp terminal and the coil through the two arms and body by the right hand being brought into contact with one terminal of the oil coil, and a piece of metal grasped in the left hand being approached to the free terminal of the lamp. At the first approach the bulb of the lamp became filled with phosphorescent light, but on reducing the distance between the metal in the left hand and the free lamp terminal, sparks shot out between them and the filament at once became incandescent, the incandescence increasing very nearly to the full normal amount when the piece of metal and the lamp terminal were finally brought into contact.

To produce a similar incandescence of the filament with continuous or alternating currents of ordinary frequency would require about one-fifth of an ampere, and at first sight it would seem that this quantity of current might pass through the arms and body of the operator.

It has been generally assumed that with high frequency currents the current is rendered harmless by reason of the high frequency, in fact, that high frequency renders harmless to the human body currents of a strength that would be dangerous and painful, if not fatal, were the frequency lower. The author is inclined to think that another explanation is possible and that the true fact is, not that high frequency renders harmless a given strength of current that with ordinary frequency would be harmful, but that with high frequency it is possible to obtain effects with exceedingly small currents, that with continuous and ordinary alternating currents can only be obtained by the use of much larger currents.

This hypothesis is probably applicable to many other high frequency effects, but as applied to the above mentioned experiment it is simply this. The lamp filament having a certain definite resistance, with continuous or ordinary alternating currents which pass uniformly or nearly so through the section of the filament, a certain amperage of current is necessary to produce the number of watts required to raise the filament to incandescence. With the high frequency currents on the other hand, as is well understood, the current travels chiefly on the outer surface of the filament, little or none passing through the central portion. The current is in fact merely skin deep. The virtual resistance is therefore very high, as only an extremely small portion of the sectional area of the filament acts as a conductor. There is an ample sufficiency of volts, and though the current is very minute there is a sufficient expenditure of watts to raise the filament to incandescence. The lamp, in fact, ceases to be a 100-volt lamp and becomes, it may well be, a 100,000-volt lamp. As confirming this hypothesis it should be mentioned that while the filament was incandescent, sparks passed between the lamp terminals which were at some distance apart, this being evidence that there was a difference of potential amounting at least to thousands of volts between the two ends of the filament.

Returning to the experiments, several other curious results were obtained. If instead of connecting the lamp to the coil through the human frame a wire was used, the filament became much brighter than in the previous experiment. In fact, it gave considerably above its normal candle power. From this it was evident that the human body offered considerable opposition of some description to the passage of the electricity. In order to form some idea of the amount of this opposition the body was again inserted in the circuit between the coil and the lamp as previously, and the thumbs of the two hands brought near together. Sparks about one-quarter of an inch in length were found to pass between them, evidencing that the two hands of the operator had a difference of potential between them apparently equal to some thousands of volts. When the sparks passed between the hands, or when the wrists were brought into contact so, as it were, to short circuit to some extent the resistance of the arms and body, the filament became very appreciably brighter. It should be mentioned that when the sparks were allowed to pass between the hands very perceptible shocks were felt in the wrists.

Another experiment was to connect one lamp terminal by a wire to the coil, connect the other lamp terminal to earth, and short circuit the lamp through the body by grasping the coil terminal with one hand and a piece of metal connected to earth with the other. The effect of so doing was to reduce the incandescence of the filament to rather less than one-half its normal amount, half of the available current going apparently through the lamp, the other half through the body.

With the lamp terminal connected to the coil, it was found unnecessary to connect the other lamp terminal to earth to produce incandescence, all that was necessary being to touch this lamp terminal with a piece of metal held in the hand. That the incandescence of the filament produced under these conditions was due to the electrostatic capacity of the operator and not to his forming a connection to earth, was evidenced by the fact that it made no perceptible difference whether he stood on the floor or on an insulated stool.

In all the above experiments the second terminal of the oil coil was free and not connected to anything. It was however found that the effect of a second operator touching this terminal, or of connecting it by wire to earth, was to diminish the incandescence of the lamp filament. It was also found that the filament incandesced to a greater degree of brightness when connected as above between one terminal of the coil and earth, than when it was directly connected between the two terminals of the coil. This seems to show that capacity has much to do with the results obtained.

It should also be mentioned that in some of the experiments there was a decided tendency for the filament to vibrate in unison with the contact breaker of the induction coil. In fact in some cases the amplitude of vibration was sufficient to cause the end of the filament to beat against the glass of the lamp bulb.

ALTERNATE CURRENTS OF HIGH POTENTIAL AND HIGH FREQUENCY.—III.

(Concluded.)

BY NIKOLA TESLA.

One of the most interesting results arrived at in pursuing these experiments, is the demonstration of the fact that a gaseous medium, upon which vibration is impressed by rapid changes of electrostatic potential, is rigid. In illustration of this result an experiment may be cited: A glass tube about 1 inch in diameter and 3 feet long, with outside condenser coatings on the ends, was exhausted to a certain point, when, the tube being suspended freely from a wire connecting the upper coating to one of the terminals of the coil, the discharge appeared in the form of a luminous thread, passing through the axis of the tube. Usually the thread was sharply defined in the upper part of the tube and lost itself in the lower part. When a magnet or the finger was quickly passed near the upper part of the luminous thread, it was brought out of position by magnetic or electrostatic influence, and a transversal vibration like that of a suspended cord, with one or more distinct nodes, was set up, which lasted for a few minutes and gradually died out. By suspending to the lower condenser coating metal plates of different sizes, the speed of the vibration was varied. This vibration would seem to show beyond doubt that the thread possessed rigidity, at least to transversal displacements.

Many experiments were tried to demonstrate this property in

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In observing the behavior of gases, and the luminous phenomena obtained, the importance of the electrostatic effects was noted and it appeared desirable to produce enormous potential differences, alternating with extreme rapidity. Experiments in this direction led to some of the most interesting results arrived at in the course of these investigations. It was found that by rapid alternations of a high electrostatic potential, exhausted tubes could be lighted at considerable distance from a conductor connected to a properly constructed coil, and that it was practicable to establish with the coil an alternating electrostatic field, acting through the whole extent of a room and lighting a tube, wherever it was placed in the same. Phosphorescent bulbs may be excited in such a field, and it is easy to regulate the effect by connecting to the bulb a small insulated metal plate. It was likewise possible to maintain a filament or button mounted in a tube at bright incandescence, and in one experiment, a mica vane was spun by the incandescence of a platinum wire.

It is hoped that the study of these phenomena, and the perfection of the means for obtaining rapidly alternating high potentials, will lead to the production of an efficient illuminant.

THE UTILIZATION OF NIAGARA.—II.

(Concluded.)

BY PROF. GEORGE FORBES, F.R.S.

Having now given some account of the hydraulic part of the work, and of the engineering construction, it will be well to say something about the manner in which this power is to be distrib-

air at ordinary pressure. Though no positive evidence has been obtained, it is thought nevertheless, that a high frequency brush or streamer, if the frequency could be pushed far enough, would be decidedly rigid. A small sphere might then be moved within it quite freely, but if thrown against it the sphere would rebound. An ordinary flame cannot possess rigidity to a marked degree because the vibration is directionless; but an electric arc, it is believed, must possess that property more or less. A luminous band excited in a bulb by repeated discharges of a Leyden jar must also possess rigidity, and if deformed and suddenly released should vibrate.

From like considerations other conclusions of interest may be made. The most probable medium filling the space is one consisting of independent carriers immersed in an insulating fluid. If through this medium enormous electrostatic stresses are assumed to act, which vary rapidly in intensity, it would allow the motion of a body through it, yet it would be rigid and elastic, although the fluid itself might be devoid of these properties. Furthermore, on the assumption that the independent carriers are of any configuration such that the fluid resistance to motion in one direction is greater than in another, a stress of that nature would cause the carriers to arrange themselves in groups, since they would turn to each other their sides of the greatest electric density, in which position the fluid resistance to approach would be smaller than to receding. If in a medium of the above characteristics a brush would be formed by a steady potential, an exchange of the carriers would go on continually, and there would be less carriers per unit of volume in the brush than in the space at some distance from the electrode, this corresponding to rarefaction. If the potential were rapidly changing, the result would be very different; the higher the frequency of the pulses, the slower would be the exchange of the carriers; finally, the motion of translation through measurable space would cease, and, with a sufficiently high frequency and intensity of the stress, the carriers would be drawn towards the electrode, and compression would result.

An interesting feature of these high frequency currents is that they allow to operate all kinds of devices by connecting the device with only one leading wire to the source. In fact, under certain conditions it may be more economical to supply the electrical energy with one lead than with two.

An experiment of special interest is the running, by the use of only one insulated line, of a motor operating on the principle of the rotating magnetic field enunciated by the author a few years ago. A simple form of such a motor is obtained by winding upon a laminated iron core a primary and close to it a secondary coil, closing the ends of the latter and placing a freely movable metal disc within the influence of the moving field. The secondary coil may, however, be omitted. When one of the ends of the primary coil of the motor is connected to one of the terminals of the high-frequency coil and the other end to an insulated metal plate, which, it should be stated, is not absolutely necessary for the success of the experiment, the disc is set in rotation.

Experiments of this kind seem to bring it within the reach of possibility to operate a motor at any point of the earth's surface from a central source, without any connection to the same except through the earth. If, by means of powerful machinery, rapid variations of the earth's potential were produced, a grounded wire reaching up to some height would be traversed by a current which could be increased by connecting the free end of the wire to a body of some size. The current might be converted to low tension and used to operate a motor or other device. The experiment, which would be one of great scientific interest, would probably best succeed on a ship at sea. In this manner, even if it were not possible to operate machinery, intelligence might be transmitted quite certainly.

In the course of this experimental study special attention was devoted to the heating effects produced by these currents, which are not only striking, but open up the possibility of producing a more efficient illuminant. It it sufficient to attach to the coil terminal a thin wire or filament, to have the temperature of the latter perceptibly raised. If the wire or filament be inclosed in a bulb, the heating effect is increased by preventing the circulation of the air. If the air in the bulb be strongly compressed, the displacements are smaller, the impacts less violent, and the heating effect is diminished. On the contrary, if the air in the bulb be exhausted, an inclosed lamp filament is brought to incandescence, and any amount of light may thus be produced.

The heating of the inclosed lamp filament depends on so many things of a different nature, that it is difficult to give a generally applicable rule under which the maximum heating occurs. As regards the size of the bulb, it is ascertained that at ordinary or only slightly differing atmospheric pressures, when air is a good insulator, the filament is heated more in a small bulb, because of the better confinement of heat in this case. At lower pressures, when air becomes conducting, the heating effect is greater in a large bulb, but at excessively high degrees of exhaustion there seems to be, beyond a certain and rather small size of the vessel, no perceptible difference in the heating.

The shape of the vessel is also of some importance, and it has

cal bulb with the electrode mounted in its centre, where the rebounding molecules collide. It is desirable on account of economy that all the energy supplied to the bulb from the source should reach without loss the body to be heated. The loss in conveying the energy from the source to the body may be reduced by employing thin wires heavily coated with insulation, and by the use of electrostatic screens. It is to be remarked, that the screen cannot be connected to the ground as under ordinary conditions.

In the bulb itself a large portion of the energy supplied may be lost by molecular bombardment against the wire connecting the body to be heated with the source. Considerable improvement was effected by covering the glass stem containing the wire with a closely fitting conducting tube. This tube is made to project a little above the glass, and prevents the cracking of the latter near the heated body. The effectiveness of the conducting tube is limited to very high degrees of exhaustion. It diminishes the energy lost in bombardment for two reasons: First, the charge given up by the atoms spreads over a greater area, and hence the electric density at any point is small, and the atoms are repelled with less energy than if they would strike against a good insulator; secondly, as the tube is electrified by the atoms which first come in contact with it, the progress of the following atoms against the tube is more or less checked by the repulsion which the electrified tube must exert upon the similarly electrified atoms. This, it is thought, explains why the discharge through a bulb is established with much greater facility when an insulator than when a conductor is present.

During the investigations great many bulbs of different construction, with the electrodes of different material, were experimented upon, and a number of observations of interest were made. It was found that the deterioration of the electrode is the less, the higher the frequency. This was to be expected, as then the heating is effected by many small impacts, instead of by fewer and more violent ones, which quickly shatter the structure. The deterioration is also smaller when the vibration is harmonic. Thus an electrode, maintained at a certain degree of heat, lasts much longer with currents obtained from an alternator, than with those obtained by means of a disruptive discharge. One of the most durable electrodes was obtained from strongly compressed carborundum, which is a kind of carbon recently produced by Mr. E. G. Acheson. From experience, it is inferred, that to be most durable, the electrode should be in the form of a sphere with a highly polished surface.

In some bulbs refractory bodies were mounted in a carbon cup and pushed under the molecular impact. It was observed in such experiments that the carbon cup was heated at first, until a higher temperature was reached; then most of the bombardment was directed against the refractory body, and the carbon was relieved. In general, when different bodies were mounted in the bulb, the hardest fusible would be relieved, and would remain at a considerably lower temperature. This was necessitated by the fact that most of the energy supplied would find its way through the body which was easier fused or "evaporated." Curiously [illegible] appeared in some of the experiments made, that a body was fused in a bulb under the molecular impact by evolution of less light than when fused by the application of heat in ordinary [illegible]. This may be ascribed to a loosening of the structure of the body under the violent impacts and changing stresses.

Some experiments seem to indicate that under certain conditions a body, conducting, or non-conducting, may, when bombarded, emit light, which to all appearance is due to phosphorescence, but may in reality be caused by the incandescence of an infinitesimal layer, the mean temperature of the body being comparatively small. Such might be the case if each single rythmical impact were capable of instantaneously exciting the retina, and the rythm just high enough to cause a continuous impression in the eye. According to this view, a coil operated by disruptive discharge would be eminently adapted to produce such a result, and it is found by experiment that its power of exciting phosphorescence is extraordinarily great. It is capable of exciting phosphorescence at comparatively low degrees of exhaustion, and also projects shadows at pressures far greater than those at which the mean free path is comparable to the dimensions of the vessel. The latter observation is of some importance, inasmuch as it may modify the generally accepted views in regard to the "radiant state" phenomena.

A thought, which early and naturally suggested itself, was to utilize the great inductive effects of high frequency currents to produce light in a sealed glass vessel without the use of leading-in wires. Accordingly, many bulbs were constructed in which the energy necessary to maintain a button or filament at high incandescence, was supplied through the glass either by electrostatic or electrodynamic induction. It was likewise easy to regulate the intensity of the light emitted by means of an externally applied condenser coating connected to an insulated plate, or simply by means of a plate attached to the bulb which at the same time performed the function of a shade.

A subject of experiment, which has been exhaustively treated by Prof. J. J. Thomson, has been followed up independently by the author from the beginning of this study, namely, to excite by electrodynamic induction a luminous band in a closed tube or bulb.

period, especially if the condenser is of very small surface and is charged to a very high potential. As many important results are dependent upon the correctness of the estimation of the vibration period, this subject demands the most careful scrutiny of other investigators.

In Leyden jars the loss due to the presence of air is comparatively small, principally on account of the great surface of the coatings and the small external action, but if there are streamers on the top, the loss may be considerable, and the period of vibration is affected. In a resonator, the density is small, but the frequency is extreme, and may introduce a considerable error. It appears certain, at any rate, that the periods of vibration of a charged body in a gaseous and in a continuous medium, such as oil, are different, on account of the action of the former, as explained.

Another fact recognized, which is of some consequence, is, that in similar investigations the general considerations of static screening are not applicable when a gaseous medium is present. This is evident from the following experiment: A short and wide glass tube is taken and covered with a substantial coating of bronze, barely allowing the light to shine a little through. The tube is highly exhausted and suspended on a metallic clasp from the end of a wire. When the wire is connected with one of the terminals of the coil, the gas inside of the tube is lighted in spite of the metal coating. Here the metal evidently does not screen the gas inside as it ought to, even if it be very thin and poorly conducting. Yet, in a condition of rest, the metal coating, however thin, screens the inside perfectly.

PROVISIONAL PROGRAMME FOR THE INTERNATIONAL ELECTRICAL CONGRESS OF 1893.

THE General Congress Committee of the American Institute of Electrical Engineers has just received the report of its sub-committee, embodying a provisional programme for the conduct and work of the Congress, to be held in Chicago during this year.

The sub-committee consisting of Mr. Carl Hering, chairman; Prof. Wm. A. Anthony and Mr. A. E. Kennelly, made the following recommendations, in the course of an admirable report:—

RECOMMENDATIONS.

(1.) *Ratification of the adoption of units, terms and definitions made by previous International Electrical Congresses.*

(2.) *Defining and adopting practical units for measuring and designating the measurements of the following quantities: Magneto-motive force; magnetic flux; magnetic intensity; magnetic reluctance; electric conductivity; illumination.*

Your Committee recommends the follo

the impulses be very small, the loss caused by the impacts and collisions would not be serious unless the potential were excessive. But when extremely high frequencies and more or less high potentials are used, the loss may be very great. The total energy lost per unit of time is proportionate to the product of the number of impacts per second, or the frequency and the energy lost in each impact. But the energy of an impact must be proportionate to the square of the electric density of the body, on the assumption that the charge imparted to the molecule is proportionate to that density. It is concluded from this that the total energy lost must be proportionate to the product of the frequency and the square of the electric density: but this law needs experimental confirmation. Assuming the preceding considerations to be true, then, by rapidly alternating the potential of a body immersed in an insulating gaseous medium, any amount of energy may be dissipated into space. Most of that energy, then, is not dissipated in the form of long ether waves, propagated to considerable distance, as is thought most generally, but is consumed in impact and collisional losses—that is, heat vibrations—on the surface and in the vicinity of the body. To reduce the dissipation it is necessary to work with a small electric density—the smaller the higher the frequency.

The behavior of a gaseous medium under such rapid alternations of potential makes it appear plausible that electrostatic disturbances of the earth, produced by cosmic events, may have great influence upon the meteorological conditions. When such disturbances occur, both the frequency of the vibrations of the charge and the potential are in all probability excessive, and the energy converted into heat may be considerable. Since the density must be unevenly distributed, either in consequence of the irregularity of the earth's surface, or on account of the condition of the atmosphere in various places, the effect produced would accordingly vary from place to place. Considerable variations in the temperature and pressure of the atmosphere may in this manner be caused at any point of the surface of the earth. The variations may be gradual or very sudden, according to the nature of the original disturbance, and may produce rain and storms, or locally modify the weather in any way.

From many experiences gathered in the course of these investigations it appears certain that in lightning discharges the air is an element of importance. For instance, during a storm a stream may form on a nail or pointed projection of a building. If lightning strikes somewhere in the neighborhood, the harmless static discharge may, in consequence of the oscillations set up, assume the character of a high frequency streamer, and the nail or projection may be brought to a high temperature by the violent impact of the air molecules. Thus, it is thought, a building may be set on fire without the lightning striking it. In like manner small metallic objects may be fused and volatilized—as frequently occurs in lightning discharges—merely because they are surrounded by air. Were they immersed in a practically continuous medium, such as oil, they would probably be safe, as the energy would have to spend itself elsewhere.

An instructive experiment having a bearing on this subject is the following:—A glass tube of an inch or so in diameter and several inches long is taken, and a platinum wire sealed into it, the wire running through the centre of the tube from end to end. The tube is exhausted to a moderate degree. If a steady current is passed through the wire it is heated uniformly in all parts and the gas in the tube is of no consequence. But if high frequency discharges are directed through the wire, it is heated more on the ends than in the middle portion, and if the frequency, or rate of charge, is high enough, the wire might as well be cut in the middle as not, for most of the heating on the ends is due to the rarefied gas. Here the gas might only act as a conductor of no impedance, diverting the current from the wire as the impedance of the latter is enormously increased, and merely heating the ends of the wire by reason of their resistance to the passage of the discharge. But it is not at all necessary that the gas in the tube should be conducting; it might be at an extremely low pressure, still the ends of the wire would be heated; as, however, is ascertained by experience, only the two ends would in such case not be electrically connected through the gaseous medium. Now what with these frequencies and potentials occurs in an exhausted tube, occurs in the lightning discharge at ordinary pressure.

From the facility with which any amount of energy may be carried off through a gas, it is concluded that the best way to render harmless a lightning discharge is to afford it in some way a passage through a volume of gas.

The recognition of some of the above facts has a bearing upon far-reaching scientific investigations in which extremely high frequencies and potentials are used. In such cases the air is an important factor to be considered. So, for instance, if two wires are attached to the terminals of the coil, and streamers issue from them, there is dissipation of energy in the form of heat and light, and the wires behave like a condenser of larger capacity. If the wires be immersed in oil, the dissipation of energy is prevented, or at least reduced, and the apparent capacity is diminished. The action of the air would seem to make it very difficult to tell, from the measured or computed capacity of a condenser in which the air [illegible]

when it is at right angles to the lines of force of the earth. It very likely rotates, when at its maximum speed, in synchronism with the alternations, say 10,000 times a second. The rotation can be slowed down or accelerated by the approach or receding of the observer, or any conducting body, but it cannot be reversed by putting the bulb in any position. Very curious experiments may be performed with the brush when in its most sensitive state. For instance, the brush resting in one position, the experimenter may, by selecting a proper position, approach the hand at a certain considerable distance to the bulb, and he may cause the brush to pass off by merely stiffening the muscles of the arm, the mere change of configuration of the arm and imperceptable displacement being sufficient to disturb the delicate balance. When it begins to rotate slowly, and the hands are held at a proper distance, it is impossible to make the slightest motion without producing a visible effect upon the brush. A metal plate connected to the other terminal of the coil affects it at a great distance, slowing down the rotation often to one turn a second.

It is hoped that this phenomenon will prove a valuable aid in the investigation of the nature of the forces acting in an electrostatic or magnetic field. If there is any motion which is measurable going on in the space, such a brush would be apt to reveal it. It is, so to speak, a beam of light, frictionless, devoid of inertia. On account of its marvellous sensitiveness to electrostatic or magnetic disturbances it may be the means ofsending signals through submarine cables with any speed, and even of transmitting intelligence at a distance without wires.

LETTERS TO THE EDITOR.

THE DRIFTLESS BALLISTIC GALVANOMETER

amperes passing through the coil, becomes within two seconds' time so hot as to scorch wood. Beyond a certain frequency, an iron core, no matter how finely subdivided, exercises a dampening effect, and it was easy to find a point at which the impedance of a coil was not affected by the presence of a core consisting of a bundle of very thin well annealed and varnished iron wires.

Experiments with a telephone, a conductor in a strong magnetic field, or with a condenser or arc, seem to afford certain proof that sounds far above the usually accepted limit of hearing would be perceived if produced with sufficient power.

The arc produced by these currents possesses several interesting features. Usually it emits a note the pitch of which corresponds to twice the frequency of the current, but if the frequency be sufficiently high it becomes noiseless, the limit of audition being determined principally by the linear dimensions of the arc. A curious feature of the arc is its persistency, which is due partly to the inability of the gaseous column to cool and increase considerably in resistance, as in the case with low frequencies, and partly to the tendency of such a high frequency machine to maintain a constant current.

In connection with these machines the condenser affords a particularly interesting study. Striking effects are produced by proper adjustments of capacity and self-induction. It is easy to raise the E. M. F. of the machine to many times the original value by simply adjusting the capacity of a condenser connected in the induced circuit. If the condenser be at some distance from the machine, the difference of potential on the terminals of the latter may be only a small fraction of that on the condenser.

But the most interesting experiences are made when the tension of the currents from the machine is raised by means of an induction coil. In consequence of the enormous rate of change obtainable in the primary current, much higher potential differences are obtained than with coils operated in the usual ways, and, owing to the high frequency, the secondary discharge possesses many striking peculiarities. Both the electrodes behave generally alike, though it appears from some observations that one current impulse preponderates over the other, as before mentioned.

The physiological effects of the high tension discharge are found to be so small that the shock of the coil can be supported without any inconvenience, except perhaps a small burn produced by the discharge upon approaching the hand to one of the terminals. The decidedly smaller physiological effects of these currents are thought to be due either to a different distribution through the body or to the tissues acting as condensers. But in the case of an induction coil with great many turns the harmlessness is principally due to the fact that but little energy is available in the external circuit when the same is closed through the experimenter's body, on account of the great impedance of the coil.

In varying the frequency and strength of the currents through the primary of the coil, the character of the secondary discharge is greatly varied, and no less than five distinct forms are observed: —weak, sensitive thread discharge, a powerful flaming discharge, and three forms of brush or streaming discharges. Each of these possesses certain noteworthy features, but the most interesting to study are the latter. Under certain conditions the streams, which are presumably due to the violent agitation of the air molecules, issue freely from all points of the coil, even through a thick insulation. If there is the smallest air space between the primary and secondary, they will form there and surely injure the coil by slowly warming the insulation. As they form even with ordinary frequencies when the potential is excessive, the air-space must be most carefully avoided.

These high frequency streamers differ in aspect and properties from those produced by a static machine. The wind produced by them is small and should altogether cease if still considerably higher frequencies could be obtained. A peculiarity is that they issue as freely from surfaces as from points. Owing to this, a metallic vane, mounted in one of the terminals of the coil so as to rotate freely, and having one of its sides covered with insulation, is spun rapidly around. Such a vane would not rotate with a steady potential, but with a high-frequency coil it will spin, even if it be entirely covered with insulation, provided the insulation on one side be either thicker or of a higher specific inductive capacity. A Crookes electric radiometer is also spun around when connected to one of the terminals of the coil, but only at very high exhaustion or at ordinary pressures.

There is still another and more striking peculiarity of such a high frequency steamer, namely, it is hot. The heat is easily perceptible with frequencies of about 10,000, even if the potential is not excessively high. The heating effect is, of course, due to the molecular impacts and collisions. Could the frequency and potential be pushed far enough, then a brush could be produced resembling in every particular a flame and giving light and heat, yet without a chemical process taking place. The hot brush, when properly produced, resembles a jet of burning gas escaping under great pressure, and it emits an extraordinary strong smell of ozone. The great ozonizing action is ascribed to the fact that the agitation of the molecules of the air is more violent in such a brush than in the ordinary streamer of a static machine.

But the most powerful brush discharges were produced by employing currents of much higher frequencies than it was possible to obtain by means of the alternators. These currents were obtained by disruptively discharging a condenser and setting up oscillations. In this manner currents of a frequency of several hundred thousand were obtained. Currents of this kind produce striking effects. At these frequencies, the impedance of a copper bar is so great that a potential difference of several hundred volts can be maintained between two points of a short and thick bar, and it is possible to keep an ordinary incandescent lamp burning at full candle power by attaching the terminals of the lamp to two points of the bar no more than a few inches apart. When the frequency is extremely high, nodes are found to exist on such a bar, and it is easy to locate them by means of a lamp.

By converting the high-tension discharges of a low-frequency coil in this manner, it was found practicable to keep a few lamps burning on the ordinary circuit in the laboratory, and by bringing the undulation to a low pitch, it was possible to operate small motors. This plan likewise allows of converting high-tension discharges of one direction into low tension unidirectional currents, by adjusting the circuit so that there are no oscillations. In passing the oscillating discharges through the primary of a specially-constructed coil, it is easy to obtain enormous potential differences with only few turns of the secondary.

Great difficulties were at the beginning experienced in producing a successful coil on this plan. It was found necessary to keep all air, or gaseous matter in general, away from the charged surfaces, and oil immersion was resorted to. The wires used were heavily covered with gutta-percha and wound in oil, or the air was pumped out by means of a Sprengel pump.

The general arrangement was the following: An ordinary induction coil, operated from a low-frequency alternator, was used to charge Leyden jars. The jars were made to discharge over a single or multiple gap through the primary of the second coil. To insure the action of the gap, the arc was blown out by a magnet or air-blast. To adjust the potential in the secondary a small oil condenser was used, or polished brass spheres of different sizes were screwed on the terminals and their distance adjusted.

When the conditions were carefully determined to suit each experiment, magnificent effects were obtained.

Two wires, stretched through the room, each being connected to one of the terminals of the coil, emit streams so powerful that the light from them allows distinguishing the objects in the room; the wires become luminous even if covered with thick and most excellent insulation. When two straight wires, or two concentric circles of wire, are connected to the terminals, and set at the proper distance, a uniform luminous sheet is produced between them. It was possible in this way to cover an area of more than one meter square completely with the streams. By attaching to one terminal a large circle of wire and to the other terminal a small sphere, the streams are focused upon the sphere, produce a strongly lighted spot upon the same, and present the appearance of a luminous cone. A very thin wire glued upon a plate of hard rubber of great thickness, on the opposite side of which is fastened a tinfoil coating, is rendered intensely luminous when the coating is connected to the other terminal of the coil. Such an experiment can be performed also with low frequency currents, but much less satisfactorily.

When the terminals of such a coil, even of a very small one, are separated by a rubber or glass plate, the discharge spreads over the plate in the form of streams, threads, or brilliant sparks, and affords a magnificent display, which cannot be equalled by the largest coil operated in the usual ways. By a simple adjustment it is possible to produce with the coil a succession of brilliant sparks, exactly like with a Holtz machine.

Under certain conditions, when the frequency of the oscillation is very great, white phantom-like streams are seen to break forth from the terminals of the coil. The chief interesting feature about them is, that they stream freely against the outstretched hand or other conducting object without producing any sensation, and the hand may be approached very near to the terminal without a spark being induced to jump. This is due presumably to the fact that a considerable portion of the energy is carried away or dissipated in the streamers, and the difference of potential between the terminal and the hand is diminished.

It is found in such experiments, that the frequency of the vibration and the quickness of succession of the sparks between the knobs affect to a marked degree the appearance of the streams. When the frequency is very low, the air gives way in more or less the same manner as by a steady difference of potential, and the streams consist of distinct threads, generally mingled with thin sparks, which probably correspond to the successive discharges occurring between the knobs. But when the frequency is very high, and the arc of the discharge produces a sound which is loud and smooth (which indicates both that oscillation takes place and that the sparks succeed each other with great rapidity), then the luminous streams formed are perfectly uniform. They are generally of a purplish hue, but when the molecular vibration is increased by raising the potential they assume a white color.

The luminous intensity of the streams increases rapidly when

the potential is increased; and with frequencies of only a few hundred thousand, could the coil be made to withstand a sufficiently high potential difference, there is no doubt that the space around a wire could be made to emit a strong light, merely by the agitation of the molecules of the air at ordinary pressure.

Such discharges of very high frequency which render luminous the air at ordinary pressure we have very likely occasion to witness in the aurora borealis. From many of these experiments it seems reasonable to infer that sudden cosmic disturbances, such as eruptions on the sun, set the electrostatic charge of the earth in an extremely rapid vibration, and produce the glow by the violent agitation of the air in the upper and even in the lower strata. It is thought that if the frequency were low, or even more so if the charge were not at all vibrating, the lower, dense strata would break down as in a lightning discharge. Indications of such breaking down have been repeatedly observed, but they can be attributed to the fundamental disturbances, which are few in number, for the superimposed vibration would be so rapid as to not allow a disruptive break.

The study of these discharge phenomena has led to the recognition of some important facts. It was found that gaseous matter must be most carefully excluded from any dielectric which is subjected to great, rapidly-changing electrostatic stresses. Since it is difficult to exclude the gas perfectly when solid insulators are used, it is necessary to resort to liquid dielectrics. When a solid dielectric is used, it matters little how thick and how good it is; if air be present streamers form, which gradually heat the dielectric and impair its insulating power, and the discharge finally breaks through. Under ordinary conditions the best insulators are those which possess the highest specific inductive capacity, but such insulators are not the best to employ when working with these high frequency currents, for in most cases the higher specific inductive capacity is rather a disadvantage. The prime quality of the insulating medium for these currents is continuity. For this reason principally it is necessary to employ liquid insulators, such as oils. If two metal plates, connected to the terminals of the coil, are immersed in oil and set a distance apart, the coil may be kept working for any length of time without a break occurring, or without the oil being warmed, but if air bubbles are introduced, they become luminous; the air molecules, by their impact against the oil, heat it, and after some time cause the insulation to give way. If, instead of the oil, a solid plate of the best dielectric, even several times thicker than the oil intervening between the metal plates, is inserted between the latter, the air having free access to the charged surfaces, the dielectric invariably is warmed and breaks down. The employment of the oil is advisable or necessary even with low frequencies, if the potentials are such that streamers form, but only in such cases, as is evident from the theory of the action. If the potentials are so low that streamers do not form, then it is even disadvantageous to employ oil, for it may, principally by confining the heat, be the cause of the breaking down of the insulation. The exclusion of gaseous matter is not only desirable on account of the safety of the apparatus, but also on account of economy, especially in a condenser, in which considerable waste of power may occur merely owing to the presence of air, if the electric density on the charged surfaces is great.

In the course of these investigations a phenomenon of special scientific interest has been observed. It may be ranked among the brush phenomena, in fact it is a kind of brush which forms at, or near, a single terminal in high vacuum. In a bulb with a conducting electrode, even if the latter be of aluminum, the brush has only a very short existence, but it can be preserved for a considerable length of time in a bulb devoid of any conducting electrode. To observe the phenomenon it is found best to employ a large spherical bulb having in its centre a small bulb supported on a tube sealed to the neck of the former. The large bulb being exhausted to a high degree, and the inside of the small bulb being connected to one of the terminals of the coil, under certain conditions there appears a misty haze around the small bulb, which, after passing through some stages, assumes the form of a brush, generally at right angles to the tube supporting the small bulb. When the brush assumes this form it may be brought to a state of extreme sensitiveness to electrostatic and magnetic influence. The bulb hanging straight down, and all objects being remote from it, the approach of the observer within a few paces will cause the brush to fly to the opposite side, and if he walks around the bulb it will always keep on the opposite side. It may begin to spin around the terminal long before it reaches that sensitive stage. When it begins to turn around, principally, but also before, it is affected by a magnet, and at a certain stage it is susceptible to magnetic influence to an astonishing degree. A small permanent magnet, with its poles at a distance of no more than two centimetres, will affect it visibly at a distance of two metres, slowing down or accelerating the rotation according to how it is held relatively to the brush.

When the bulb hangs with the globe down, the rotation is always clockwise. In the southern hemisphere it would occur in

Nikola Tesla.

THE Tesla lecture was a notable feature of the convention. At first it had been proposed to deliver the lecture in a small hall, but the demand for tickets was so enormous that it was decided, as a matter of sheer necessity, to secure a larger auditorium, and this was found in the Exhibition Theatre, which seats about 4,000 people. It was, of course, practically impossible that all could hear and see, but those who were there could at least say they had seen Mr. Tesla afar off and witnessed some of his most striking experiments. The hall was crowded to suffocation. and the demand for tickets was so great that they were selling briskly for three and five dollars on the steps of the hall. Under such circumstances Mr. Tesla contented himself wisely with showing some of the more "spectacular" of his experiments, and even these were followed at a disadvantage in view of the immense distance from which most of the spectators studied them. After his introduction by Mr. Ayer, the lecturer gave a few minutes to a statement of the conditions involved in his work, and then by means of his high frequency and high voltage currents, aided by disruptive discharge from a condenser through an induction coil—as well as by direct dynamic phenomena, he produced a number of the interesting results that have already made his name famous and have charmed two worlds. He received, unhurt, currents of hundreds of thousands of volts, lit up tubes and lamps through his body, rendered insulated wires several feet long entirely luminous, showed a motor running under the influence of these million-frequency currents, obtained a number of effects with phosphorescent lamps; and also showed how little in such work the high resistance of the filament had to do with the lighting up of ordinary 50 or 110 volt lamps. His ability to produce such effects, either with a single wire and no return, or without any wires at all, aroused the utmost interest and enthusiasm and the concluding demonstration literally brought down the house, when he showed how by simply carrying lamps or tubes into a room or hall where those currents were being developed, illumination was the immediate result.

In his opening remarks Mr. Tesla enlarged upon the grandeur of Nature, and expressed his opinion that the most wonderful of the external influences that affect us is light. Hence it followed that the most wonderful and important of the organs by which these external influences beat in upon us is the eye. Two facts were specially referred to, one of them being that the eye is the only organ capable of being affected directly by the vibrations of the ether. Another fact was that the eye would be able to distinguish objects at almost any distance, were it not for the minute particles and stray gases filling the intervening space. These absorb the energies of the ether vibrations, but in a pure medium they would travel unchecked, and the range of vision would be infinitely greater. Mr. Tesla then alluded to the importance of the part played by the eye in furnishing the race with its ideas and knowledge, and to its vital function in controlling all our motions and actions. From its teaching were derived consciousness, ideas, conceptions that were impossible without images—and images involved sight.

By these interesting stages, Mr. Tesla led up to the subject of light and thence to the part of electricity in giving us light. The general aim of the discourse was to show and explain the phenomena due to electrostatic forces, followed by phenomena produced by electro-dynamic agencies; and, then, as a third class, the light effects, Mr. Tesla's idea evidently being to give a generalization of these phenomena, and of their relations. It was stated, parenthetically, with regard to the physiological effects produced with the high tension, high frequency currents employed, that a great amount of energy may be sent into the body of a person by their means, merely because the energy was dissipated laterally from the body and was not passed through the body in the direct manner involved in the use of a low frequency current. It was due to this intense rapidity of vibration that the lecturer was able to receive with impunity currents of as high as 250,000 and 300,000 volts, and of an amount which otherwise administered would kill. The lecturer explained that he had so arranged his apparatus that in case of any failure of any part of it, the current would kindly abstain from killing him, and would only knock him down.

Many of the experiments shown have already been seen either in this country or in Europe, yet there were several novel effects introduced and even the familiar experiments were performed with apparatus different from that used before. In most of the experiments the ordinary alternating and continuous currents from the central station were used, although Mr. Tesla also had his own special generator running in the basement.

A striking new experiment was to show at the beginning of the lecture, the effect of a varying electrostatic stress through the dielectric. This experiment was performed by grasping one terminal of the high tension transformer giving about 200,000 volts pressure, and approaching the other hand, to the opposite terminal. Streams of violet light then issued from the fingers and the whole hand. (At the lecture on the preceding Friday at the Franklin Institute in Philadelphia, Prof. Houston noticed these streams of light coming also from the lecturer's back, following roughly the line of the vertebral column).

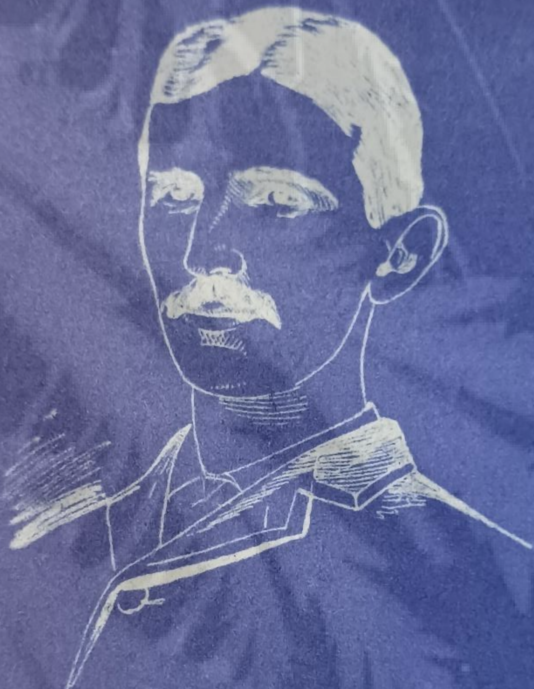
Another experiment was performed showing the action of the air between two condenser plates. By attaching these plates to the high-tension transformer, the whole space between these plates was filled with light, the distance apart being about ten inches. It was pointed out that these streamers consumed considerable energy and developed abundantly ozone and nitrous acid, and it followed that it was necessary to exclude air from high-tension apparatus.

The action of the air was shown in another very striking experiment. Two incandescent lamps exactly alike, one exhausted, the other not, both of the ordinary 50 volt type, were attached in multiple arc, and a current vibrating about one million times a second or thereabouts was passed through the filament. It was demonstrated that the lamp which was exhausted glowed brightly, whereas the other one in which the filament was surrounded by air, at ordinary pressure, did not glow. Yet the latter lamp got hotter than the other. This showed the great importance of the rarefied gas in the heating of a conductor, and it was pointed out that in incandescent lighting a high resistance filament does not at all constitute the really essential element of illumination, along these lines. Also that heavy blocks of metal may be brought to incandescence by minute currents provided they are surrounded by rarefied gas, and provided the potential and frequency of the currents is sufficiently high.

One of the most interesting experiments was the conversion on open circuit. A transformer was taken and the current passed through the high tension winding in such a way that only one terminal was attached to the source of the rapidly alternating current. In spite of this there was a current passing through the primary as though the other terminal was actually attached to the source like an ordinary return circuit. This open circuit transformer contained a secondary low tension winding, and the minute currents passing through the primary were transformed into currents capable of following the ordinary electric wire and lighting up brilliantly an ordinary lamp. It was pointed out that under certain conditions, indeed, such a conversion was quite practicable and that it can be practised with high economy. It was further pointed out that any kind of device such as motors, etc., may be operated in this manner, with one wire or circuit only.

Mr. Tesla in the course of his lecture dwelt upon his method of conversion by means of disruptive discharges from continuous or alternating station supply. There were two kinds of apparatus on the stage, one operated from the alternating circuit and the other from the regular direct current system. A peculiar form of discharger was used contained in a mica-lined wooden box. The spark-gap was warmed by a small lamp underneath, for the purpose of making the air dielectrically weak. This enabled Mr. Tesla to work with a very long gap, a very sensitive arc, and a comparatively small electromotive force in the gap. The effects obtained were thus augmented very materially. It was pointed out that with this method of conversion, there is no difficulty whatever in obtaining sparks of any length. It becomes simply a question of the energy supplied, through what distance the spark will be visible. During the lecture, lamps were operated by this method of conversion. An ordinary 100-volt, a 50-volt and a two-volt lamp were brought up to full candle-power with equal facility. Then a little motor was run by means of these disruptive discharges, it being a phase-motor comprising simply an iron core with a closed secondary coil in it, and a disc armature arranged to rotate above the core. Mr. Tesla remarked rather naïvely that if the demonstration were not quite equal to the expectation, the long continued and weary work on the development of the invention, besides the inability of the experimenter, might be the cause. He went on, in connection with this, to refer to the transmission of power from Niagara and gracefully recognized the presence on the platform of Prof. George Forbes, who is so prominently identified with this great work. Mr. Tesla believed that we were about to see such great powers transmitted long distances, and over one wire.

Continuing, Mr. Tesla remarked that he had shown things of a more spectacular nature with reluctance, yet forced thereto by the desire to gratify those who had shown their interest and formed so large an audience. A number of experiments were performed not seen in this country before, though some had been shown in England. For instance, a



Nikola Tesla.

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bulb was lighted up by being merely held in the hand, and this was a most successful experiment. Mr. Tesla prefaced it by relating a little anecdote of Lord Rayleigh. When he was in London, remarked Mr. Tesla, with much feeling, he had the pleasure of performing this experiment privately before Lord Rayleigh, and he would always remember the trembling eagerness and excitement with which that distinguished scientist witnessed the lamp light up. The appreciation of such men, said Mr. Tesla, repaid him fully for the pains he had been at in working out these phenomena.

In this experiment a number of tubes were taken and flourished or flashed in various ways, and with the current made intermittent at longer intervals by adjusting the spark-gap. Wonderfully beautiful effects were thus produced, the light of the whirled tube being made to look like the white spokes of a wheel of glowing moonbeams. Then some rectangular tubes were taken and flashed or whirled so as to produce curious designs of luminous lines.

A bulb was shown by Mr. Tesla said by him to be so highly exhausted that when the bulb was merely attached to one terminal of the disruptive discharge coil, it would send the sparks across the outside of the globe to the other terminal, which was on the opposite end, rather than pass through the bulb. The bulb in question was painted on one side with a phosphorescent powder, or mixture, and threw a most dazzling light, far beyond that yielded by any ordinary phosphorescence. It was pointed out that there was no difficulty whatever in obtaining powerful phosphorescent effect in this way, and that a practical illuminant on these lines needed merely the perfection of the method of conversion above alluded to.

In conclusion the lecturer made fine cotton-covered wires stretched on a frame over the table luminous so that in the dark they looked like attenuated violet caterpillars yards long; and then within a large rectangle formed by such wires he flourished tubes in the interspace, these tubes flashing with light wherever waved.

After the lecture, so great was the desire of the public to see Mr. Tesla closer, an informal reception was held in the lobby when several hundreds of the leading citizens seized the opportunity and Mr. Tesla's hand in a very vigorous manner.

It should be added that the Electrical Exchange, of St. Louis, presented Mr. Tesla at the beginning of the lecture with a magnificent floral shield, wrought in white carnations with a border of palms and American Beauty roses. It was about four feet in diameter. In the centre was a circle of red carnations bordering a tablet of white ones, beaing the letters in red $C = \frac{E}{R}$.

Around the circumference were the floral letters: "St. Louis Electrical Exchange 1893."

THE CONNECTING LINK BETWEEN CHICAGO AND DETROIT.

...ly apparent that the Company's General Manager, Mr. Wessels, is leaving nothing undone to put within the easy reach of every railway manager a thoroughly reliable air-brake. Tho[illegible] who know his executive ability do not doubt his success and cheerfully credit him with highly useful and important pioneer work. The Company is also to be congratulated upon having such an able Superintendent as Mr. Henry P. Merriam, whose well-known mechanical and engineering ability has put him in the front rank in the street railway field,

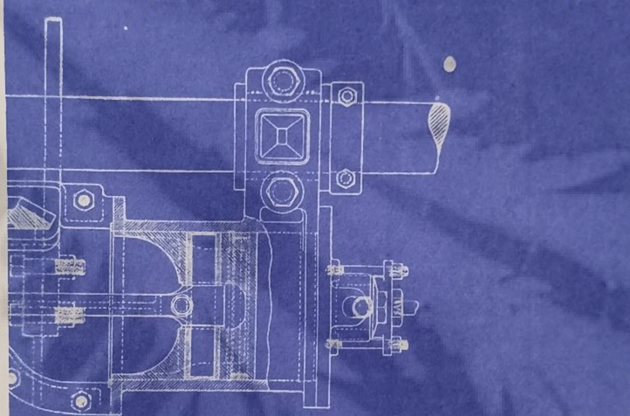
POWER TRANSMISSION.

TESLA ON ELECTRICITY WITHOUT WIRES.

Mr. Tesla thus writes the New York *Herald* under date Dec. 31:—

In reply to your question as to what discovery would do most to better our condition, in my opinion the demonstration that the earth's electrical charge can be distributed, and thereby electrical waves efficiently transmitted to any distance without the use of cables or wires, would be the most beneficial.

The conveying of motive power from sources such as Niagara in this manner to any place, however remote, would increase many times the productive capacity of mankind. It would bring millions of miserable creatures from the darkness of the coal pits to the light of day. It would cause a kinder feeling to spring up



BRAKE COMPRESSOR.

etween the weak and the strong, which would lead to a generous djustment of the evermore difficult questions of labor and capital.

Even if power could not be distributed, the mere transmission f intelligible signals would be of incalculable benefit. Such a ealization would do away with the instability of the financial narkets, which is the cause of much suffering and misery. It ould greatly facilitate the evolution of novel ideas, as well as ne prevention of evils. It would increase the safety of travel nd give a new impetus to the press and spread of knowledge. he first message transmitted would be the signal to general isarmament and a closer union of nations, and the words of the reat German poet, "Seid umschlungen Millionen, diesen Kuss er ganzen Welt," would be deeply felt everywhere.

Our present knowledge is sufficient to fill us with the conviction that the solution of these important problems is not far off. ay the new year witness these triumphs.

TO MAKE CHLORATE OF POTASH AT NIAGARA.

Secretary Rankine, of the Niagara Falls Power Company, has nounced that his company has made a contract with Walton rguson of New York City, under which Mr. Ferguson will erect actory for the manufacture of chlorate of potash on the lands the power company and use from 500 to 8,500 H. P. The site ected is to the east of the new calcic carbide plant and covers acre of ground to start with. The buildings will be put up at ce.

Ricardo Zuloaga, of Caracas, Venezuela, has been at the Falls th Mr. W. B. Wreaks of the Westinghouse Electric and Manuturing Company to view the power installation there. Mr. loaga is a member of the "Compania Anonima La Electrici-d," of Caracas. This company has a project to develop power

LEGAL NOTES.

THE TESLA POLYPHASE PATENTS.

The General Electric Co. has been granted more time, viz., until Nov. 16, to file evidence in the suit of the Westinghouse Co. against it for infringement of the Tesla patents; and the plaintiffs have twenty days thereafter for cross-examination. The original limit was Oct. 7.

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AUTO-CARS.—By L. Serrallier. Trans. by D. [illegible] E. E. New York. Whittaker & Co. 1896. Cloth. 8vo. Illus. 249 pages. Price, $1.50.

This is a timely and interesting book, which we can cordially recommend to all interested in this important subject, about which information is so scarce. Much is written, but little is known. Indeed, a melancholy feeling comes over one in looking through these pages to note how many types are impossible, how many are too expensive, and how few combine inventive ideas with mechanical knowledge. Most of the automotors here shown will go into the scrap heap in a year or two, but the art will rear itself on their remains. The record is fairly complete in this volume, although, as it was first published in France it is not surprising to see several American machines electric and other, omitted from the enumeration.

LEGAL NOTES

THE TESLA PATENTS REVOKED IN GERMANY.

The Elektrotechnische Zeitschrift quoting the Köln. Ztg. states that the suit of the Allgemeine Elektricitäts-Gesellschaft of Berlin against the Aktien-Gesellschaft Helios of Cologne, for the revocation of the Tesla patents was tried before the German Patent Office and resulted in the revocation of the patents according to paragraph 11 of the German Patent Laws. The case will be appealed to the Imperial Court by the Helios Company. Just what "Tesla patents" were revoked is not stated. The term is usually applied in this country to those dealing with induction motors requiring phase currents for their operation.

The paragraph of the German Patent Law above referred to reads as follows.

§ 11. A patent can be revoked after the expiration of three years, reckoned from the date of publication of allowance.

1. If the patentee fails to carry out his invention in Germany to a suitable extent, or at least to do everything that is necessary to ensure its being carried out.

2. If the grant of license to others for using the invention appears to be demanded in the interest of public welfare, but the patentee nevertheless refuses to grant such license upon adequate compensation and against sufficient security.

WALKER CO. VS. GLENOAKS AND PROSPECT HEIGHTS RY. CO.—A SUIT FOR BREACH OF CONTRACT.

Mr. J. H. Gates, the Chicago representative of the Walker Company, of Cleveland, Ohio, informs us that they have begun an assumpsit suit for $15,000 against the Glen Oaks and Prospect Heights Railway Company, J. H. Seiberling, M. Seiberling, A. G. Seiberling and F. Patee, all of Peoria, Ill., for breach of contract. It appears that the Walker Company contracted with the parties named for generators and motors, and that the order was cancelled without any cause. The Walker Company are making a test case of this, and have engaged the services of several leading lawyers. It is said that a decision for the plaintiffs will put a salutary check on the practice indulged in by some companies of ordering apparatus and then repudiating the contract even after the machinery has been built, but without any justifiable cause.

ONNECTICUT TROLLEY PARALLELS.

HON. GEORGE S. HALE, of Boston, who died suddenly last week at his Bar Harbor cottage, was the father of Mr. R. S. Hale, the well known electrical and steam engineer, for whom deep regrets are felt at this heavy and serious loss.

NEWS AND NOTES

TESLA ELECTRIFIES THE EARTH.

According to the New York "Journal," of August 4, Mr. Tesla announces the completion of his work for the transmission of messages from one point to another on the earth, without the aid of wires. To give an idea of the high potential currents used in this work, he showed a large disc, from the center of which protruded a spherical electrode shooting forth long streams of ethereal flame. Mr. Tesla stated that the electrical disturbance thus created was felt throughout the globe. The article is graphically illustrated with a large picture of the contrivance for emitting the discharge.

THE STOCK MARKET

POWER TRANSMISSION

TESLA'S HIGH POTENTIAL TRANSFORMER.

IN his experiments involving high potentials Mr. Nikola Tesla has for some time past made use of a special form of induction coil, and in a recent patent issued to him he describes several forms specially adapted to be used in connection with a system of high potential power transmission. To accomplish the desired object Mr. Tesla employs an induction coil or transformer in which the primary and secondary coils are wound in such manner that the convolutions of the conductor of the latter will be farther removed from the primary as the liability of injury from the effects of potential increases, the terminal or point of highest potential being the most remote, and so that between adjacent convolutions there shall be the least possible difference of potential.

The type of coil in which the last named features are present is the flat spiral, and this form Mr. Tesla generally employs, winding the primary on the outside of the secondary and taking off the current from the latter at the center or inner end of the spiral.

In constructing his improved transformers Mr. Tesla employs a length of secondary which is approximately one-quarter of the wave length of the electrical disturbance in the circuit including the secondary coil, based on the velocity of propagation of electrical disturbances through such circuit, or, in general, of such length that the potential at the terminal of the secondary which is the more remote from the primary shall be at its maximum. In using these coils the inventor connects one end of the secondary, or that in proximity to the primary, to earth, and in order to more effectually provide against injury to persons or to the apparatus he also connects it with the primary.

The accompanying diagram, Fig. 1, illustrates the plan of winding and connection employed in constructing the improved coils and the manner of using them for the transmission of energy over long distances.

A designates a core, which may be magnetic, around which the coil B is wound in spiral form. C is the primary, which is wound around in proximity to the secondary. One terminal of the latter will be at the center of the spiral coil, and from this the current is taken to line. The other terminal of the secondary is connected to earth and also to the primary.

When two coils are used in a transmission system in which the currents are raised to a high potential and then reconverted to a lower potential, the receiving transformer will be

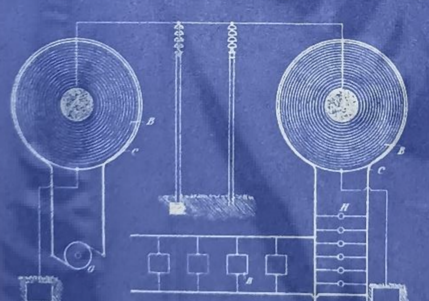


FIG. 1.—TESLA HIGH POTENTIAL TRANSMISSION SYSTEM.

constructed and connected in the same manner as the first—that is to say, the inner or center end of what corresponds to the secondary of the first will be connected to line and the other end to earth and to the local circuit or that which corresponds to the primary of the first. In such case also the line wire should be supported in such manner as to avoid loss by the current jumping from line to objects in its vicinity and in contact with earth—as, for example, by means of long insulators, mounted, preferably, on metal poles, so that in case of leakage from the line it will pass harmlessly to earth. In Fig. 1, where such a system is illustrated, a dynamo G is rep-

POWER TRANSMISSION

TESLA'S HIGH POTENTIAL TRANSFORMER.

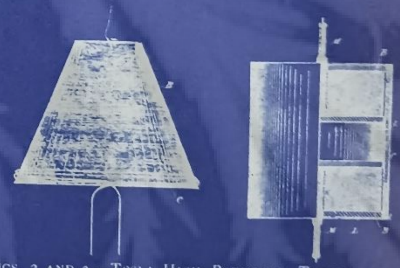
resented as supplying the primary of the sending or "step-u[p]" transformer and lamps H and motors K are shown as conne[ct]ed with the corresponding circuit of the receiving or "ste[p]-down" transformer.

Instead of winding the coils in the form of a flat spiral t[he] secondary may be wound on a support in the shape of a fru[s]tum of a cone and the primary wound around its base, [as] shown in Fig. 2.

In practice for apparatus designed for ordinary usage t[he] coil is usually constructed on the plan illustrated in Fig. [3]. In this figure L L are spools of insulating material upon whi[ch] the secondary is wound—in the present case, however, in tw[o] sections, so as to constitute really two secondaries. The pri[]mary C is a spirally-wound flat strip surrounding both secon[d]aries B. The inner terminals of the secondaries are led o[ut] through tubes of insulating material M, while the other or ou[t]side terminals are connected with the primary.

The length of the secondary coil B or of each secondary co[il] when two are used, as in Fig. 3, is, as before stated, approx[i]mately one-quarter of the wave length of the electrical di[s]turbance in the secondary circuit, based on the velocity of pr[o]pagation of the electrical disturbance through the coil itse[lf] and the circuit with which it is designed to be used—that [is] to say, if the rate at which a current traverses the circui[t] including the coil, be 185,000 miles per second, then a fre[]quency of 925 per second would maintain 925 stationary wave[s] in a circuit 185,000 miles long, and each wave length would b[e] 200 miles in length. For such a frequency Mr. Tesla woul[d] use a secondary 50 miles in length, so that at one terminal th[e] potential would be zero and at the other maximum.

Coils of this character, according to Mr. Tesla, have severa[l]



FIGS. 2 AND 3.—TESLA HIGH POTENTIAL TRANSFORMERS.

important advantages. As the potential increases with the number of turns the difference of potential between adjacent turns is comparatively small, and hence a very high potential, impracticable with ordinary coils, may be successfully maintained. As the secondary is electrically connected with the primary the latter will be at substantially the same potential as the adjacent portions of the secondary, so that there will be no tendency for sparks to jump from one to the other and destroy the insulation. Moreover, as both primary and secondary are grounded and the line-terminal of the coil carried and protected to a point remote from the apparatus the danger of a discharge through the body of a person handling or approaching the apparatus is reduced to a minimum.

TESTING THREE-PHASE INDUCTION MOTORS—TRANSFORMER CONNECTIONS...

of the latter will be at the center of the spiral coil, and from this the current is taken to line. The other terminal of the secondary is connected to earth and also to the primary.

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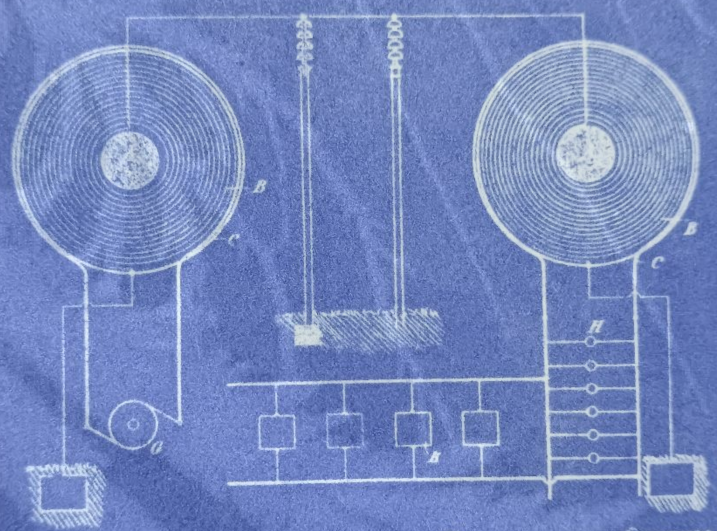
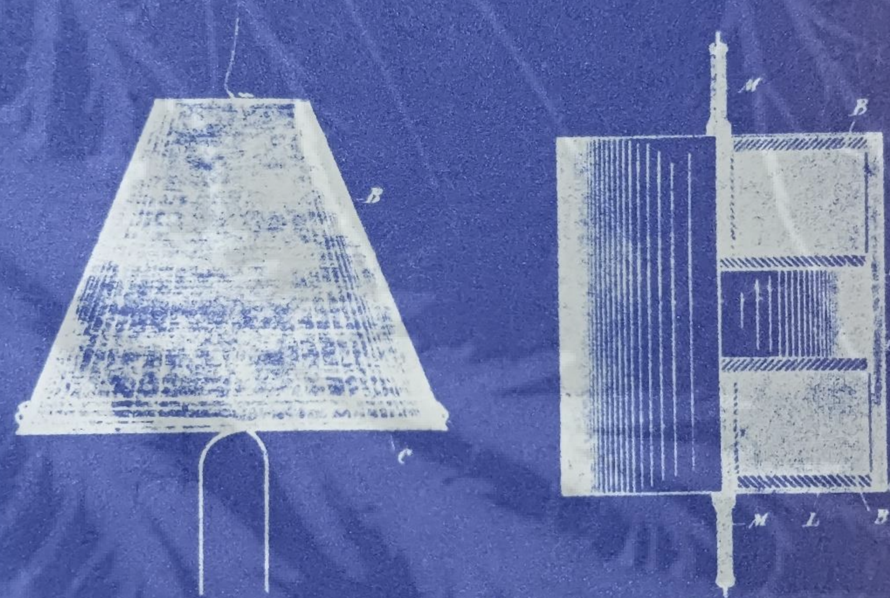


FIG. 1.—TESLA HIGH POTENTIAL TRANSMISSION SYSTEM.

constructed and connected in the same manner as the first—that is to say, the inner or center end of what corresponds to the secondary of the first will be connected to line and the other end to earth and to the local circuit or that which corresponds to the primary of the first. In such case also the line

and the circuit with which it is designed to be used—that to say, if the rate at which a current traverses the circui including the coil, be 185,000 miles per second, then a fr quency of 925 per second would maintain 925 stationary wave in a circuit 185,000 miles long, and each wave length would b 200 miles in length. For such a frequency Mr. Tesla woul use a secondary 50 miles in length, so that at one terminal th potential would be zero and at the other maximum.

Coils of this character, according to Mr. Tesla, have severa



FIGS. 2 AND 3.—TESLA HIGH POTENTIAL TRANSFORMERS.

important advantages. As the potential increases with the number of turns the difference of potential between adjacent turns is comparatively small, and hence a very high potential, impracticable with ordinary coils, may be successfully maintained. As the secondary is electrically connected with the primary the latter will be at substantially the same potential

including the coil, be 185,000 miles per second, then a fre-
quency of 925 per second would maintain 925 stationary wav
in a circuit 185,000 miles long, and each wave length would
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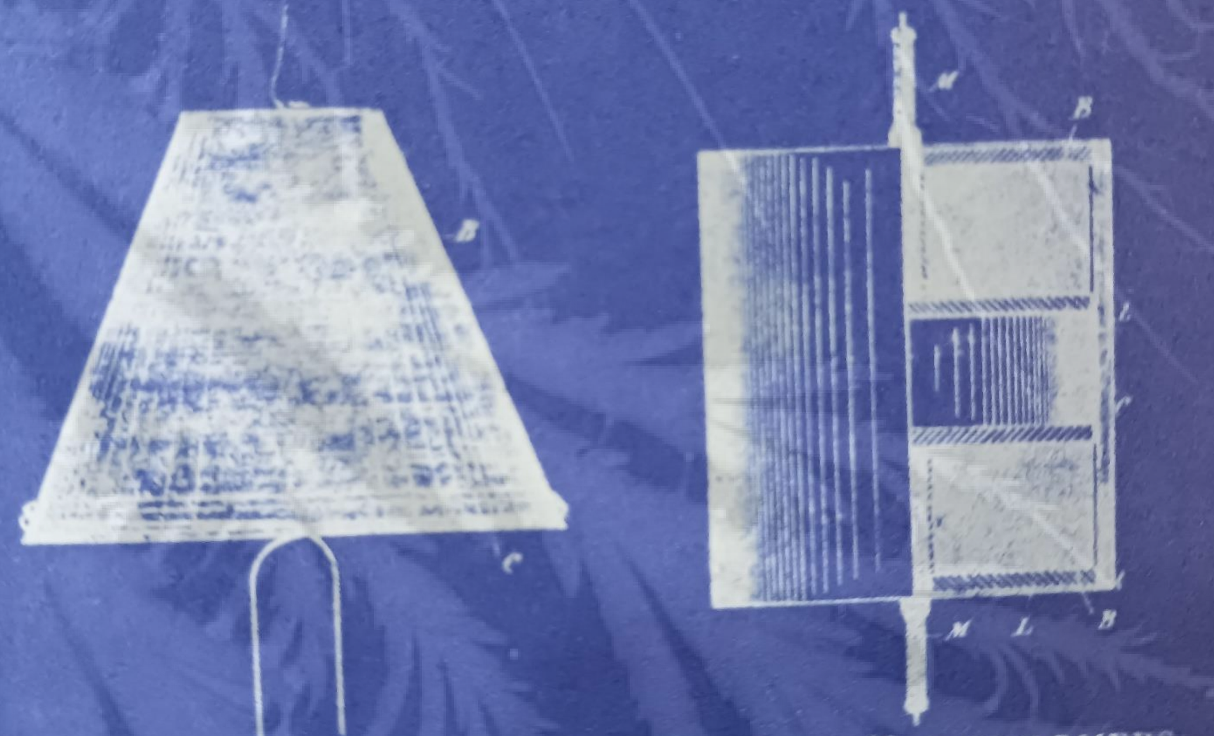


FIGS. 2 AND 3.—TESLA HIGH POTENTIAL TRANSFORMERS.

As the potential increases with

phone work by putting on such operators four hours per day, in two shifts of two hours each, besides the employment of a telephone which permits the changing of the ear at will.

MR. TESLA ON X-RAY BURNS.

It may be considered a rule of nature that every beneficent manifestation of force may be accompanied by deleterious effects unless guarded against by suitable precautions, and the Röntgen ray is no exception to the rule. The very earliest experimenters in this field noted a harmful action of the rays on the skin, but of late instances have been reported of serious injury due to so-called X-ray burns. It is probable that the cases mentioned are due more to neglect or improper treatment of the injury than to the original effect of the "burn;" nevertheless, it is eminently desirable that all possible means be adopted for the prevention of the injury to begin with, on the old principle that an ounce of prevention is better than a pound of cure. Mr. Nikola Tesla has doubtless done as much X-ray work as any one, and with apparatus whose sheer power has probably not been exceeded by that of any worker in this field and invariably without harmful results, when certain precautions were taken. The means employed with such good results, and their raison d'être, are described in an interesting communication appearing in our contemporary, The Electrical Review.

For the prevention of X-ray burns Mr. Tesla finds that a chief precaution is to interpose between the bulb and the person a thin sheet of aluminum or aluminum wire gauze, connected to the ground directly or through a condenser. This screen, according to Mr. Tesla, prevents the formation of electro-static streamers, which would otherwise issue from the body, and which have an irritating effect. In the course of his experiments, Mr. Tesla observed, however, that the injurious effects did not seem to diminish gradually with the distance from the terminal, but ceased abruptly. He accounts for this as due to the effect of the ozone generated, and supports this view by the fact that the generation of ozone ceases at a definite distance from the terminal.

But perhaps the most striking fact developed by Mr. Tesla in these investigations is, that bulbs containing platinum electrodes are more injurious that those provided with alu-

minum electrodes, in support of which assertion he cites a number of experiments.

To sum up, Mr. Tesla advises: 1. The abandonments of bulbs containing platinum. 2. The substitution for them of a properly constructed Lenard tube, containing pure aluminum only. 3. The use of a protecting aluminum screen, as indicated above, or, instead of this, a wet cloth or a layer of fluid. 4. Exposure at no less distance than 14 inches, and preferably to expose longer at a greater distance. As regards other physiological influences of the X-ray, Mr. Tesla records the fact that since he has begun to work with the X-rays his health has been improved and he has been entirely relieved of a troublesome cough; this same effect was observed on another person. He has also observed that when the head is brought close to a powerful tube the effect is similar to that produced when working for some time with a noisy air gap. As the X-ray tube gives forth no sound, Mr. Tesla concludes that the tube produces violent explosions and concussions, which, though they are inaudible, have some effect on the bony structure of the head. Their inaudibility, he explains on the assumption that not air, but some finer medium, is concerned in their propagation. In conclusion, it may be stated that Mr. Tesla still adheres to his oft-expressed opinion, that the X-ray tube when in action emits a stream of small material particles. Some of his experiments would seem to indicate that these particles start from the outer wall of the tube; others again seem to prove that there is an actual penetration of the wall, and, in the case of a thin aluminum window, Mr. Tesla has not the least doubt that some of the finely disintegrated cathodic matter is actually forced through. Mr. Tesla stands practically alone in his advocacy of the corpuscular theory of the Röntgen rays, but his faith in its correctness seems to be growing stronger as time passes and his experiments multiply.

FALSE TEACHERS.

...pair Screw Driver and ...amp Socket.

... been called upon to insert a fuse into ... a ceiling or some other place, diffi... when the place was dark, has felt the ...ol and a light to aid him in performing ... Such a tool, which seems to fill this long-...ly, has lately been placed on the market ... management of the Bartow Electric ...ew, Pa., and is illustrated below.

... requisites for enabling an operator to tap ... give light during the making of branch ...fecting of repairs. It consists of a screw ...cribed in Fig. 2, which has a detachable ...ich is hollow, contains the necessary fuses

Tesla's Electrical Control of Moving Vessels or Vehicles from a Distance.

In view of the public interest of late in anything which has a warlike appearance or appearance tending to render war less probable by making it more horrible and destructive, and in view also of numerous recent disasters at sea, the current descriptions in the daily papers of a new invention of Mr. Tesla and reported interviews with him have been received with widely differing comments. In Mr. Tesla's own words, the invention consists of a complete and practicable solution of the problem of controlling from a given point the operation of the propelling engines, the steering apparatus and other mechanism carried by a moving object, such as boat or floating vessel, whereby the movement and the course of such a vessel may be directed and controlled from a distance, and any de-

...and Lamp Attached. Fig. 2.—Screw Driver with Contents Enclosed. Fig. 3.—Replacing a Blown Out Fuse.

BAGGETT FUSE AND REPAIR OUTFIT.

...Figs. 1 and 4, for tapping the legs of the ...ps can be connected to the lamp-plug ...ase of the handle itself, by means of plugs. ...serting a lamp into this socket will have ...ht even during the operation of inserting a ...using the tool and attaching the clamps to ...own in Figs. 3 and 4. The tool has been

...PAIR SCREW DRIVER, CASE RE... ...P CAP AND WIRE CLAMP.

... view of embodying in the smallest ...ssary implements, and should find a ...s and engineers.

... gnawing at the insulation on one ...short-circuited a section of the elec... ...ble was the penalty, but the cable ...been very heavily protected.

...he Littleton Water and Electric ... water power, putting in Rodney ...developing about 350 h. p. under ...lant of the Stanley two-phase sys-

vice carried by the same brought into action at any desired time. The system is based on the use, upon the object to be exploded or steered, of a Branly coherer and Marconi agitator of novel form, toward which impulses are sent from a Hertzian radiator. It will be remembered that this is what was done in a small but very successful way at the Electrical Exhibition in Madison Square Garden last May, when miniature floating torpedoes fastened on a board floating under the bottom of model men-of-war were thus blown up daily, without wires, by means of the same "wireless telegraph" methods, from a distance of not less than 50 or 60 feet. Mr. Tesla's application is dated in July. It was one of the intentions at the exhibition to place all the receiving apparatus on the boat in the water; but for obvious reason pertinent to the locality it was found desirable to run the boat connections to a temporary shelf at the top edge of the tank and rest the coherer apparatus there; so that the floating mines or torpedoes could be renewed frequently and also to prevent the boat from floating about, as one or two people were hurt by flying pieces when the explosions took place too near the sides. Another object was to prevent the continuous destruction of the coherers, being delicate and expensive apparatus then not readily obtainable. Mr. Tesla in his scheme embodies the idea of placing the coherer on the floating torpedo, and proposes that the impulses taken up by the coherer shall also operate steering magnets, as in other dirigible torpedoes, such as the Sims-Edison, but without the wires to shore. This method he elaborates with wonted ingenuity, although he does not include the firing of artillery, which was also done last May at the exhibition, and of course might be done with equal facility on a floating ship, without wires from the shore; or on a submerged fort or an uninhabited monitor at a harbor entrance. His patent is limited merely, it would appear, to devices or mechanism for steering, and does not claim either the discharge of explosives or selective signaling, or other features of that kind.

Referring to Fig. 1, A designates any type of vessel or vehicle which is capable of being propelled and directed, such as a boat, a balloon, or a carriage. It may be designed to carry in a suitable compartment B objects of any kind, according to the nature

of the uses to which it is to be applied. The vessel—in this instance a boat—is provided with suitable propelling machinery, which is shown as comprising a screw propeller C, secured to the shaft of an electromagnetic motor D, which derives its power from storage batteries E E E E. In addition to the propelling engine or motor the boat carries also a small steering motor F, the shaft of which is extended beyond its bearings and provided with a worm which meshes with a toothed wheel G. This latter is fixed to a sleeve b, freely movable on a vertical rod H, and is rotated in one or the other direction, according to the direction of rotation of the motor F.

The sleeve b on rod H is in gear, through the cog-wheels H' and H", with a spindle G, mounted in vertical bearings at the stem of the boat and carrying the rudder F'.

The apparatus by means of which the operation of both the

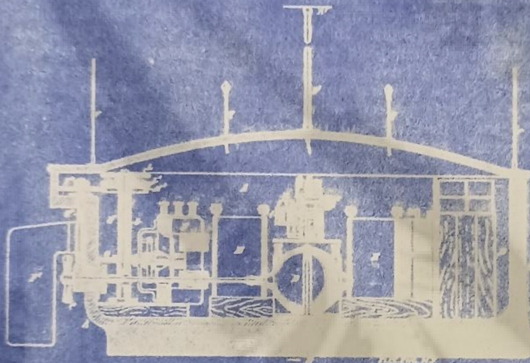


FIG. 1.

propelling and steering mechanisms is controlled involves a receiving circuit, adjusted and rendered sensitive to the influence of waves or impulses emanating from a remote source, the adjustment being so that the period of oscillation of the circuit is either the same as that of the source or a harmonic thereof.

The receiving circuit proper (diagrammatically shown in Fig. 2) comprises a terminal E', conductor C', a sensitive device A', and a conductor A", leading to the ground conveniently through a connection to the metal keel B' of the vessel. The terminal E' should present a large conducting surface and should be supported as high as practicable on a standard D', which is shown as broken in Fig. 1; but such provisions are not always necessary. It is important to insulate very well the conductor C' in whatever manner it be supported.

The circuit or path just referred to forms also a part of a local circuit, which latter includes a relay magnet a and a battery a', the electromotive force of which is, as before explained, so determined that although the dielectric layers in the sensitive device A' are subjected to a great strain, yet normally they withstand the strain and no appreciable current flows through the local circuit; but when an electrical disturbance reaches the circuit the dielectric films are broken down, the resistance of the device A' is suddenly and greatly diminished, and a current traverses the relay magnet A.

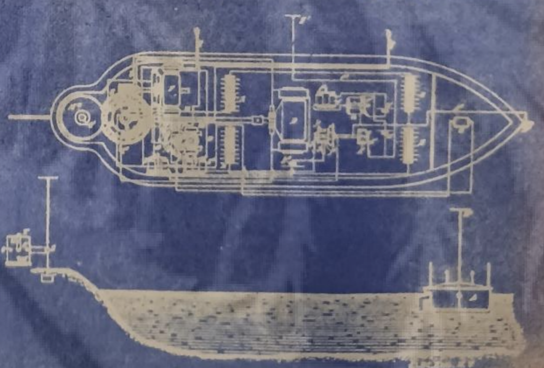
The particular sensitive device employed consists of a metal cylinder, with insulating heads, through which passes a central metallic rod. A small quantity of grains of conducting material, such as an oxidized metal, is placed in the cylinder. A metallic strip, secured to an insulated post, bears against the side of the cylinder, connecting it with one part of the circuit. The central rod is connected to the frame of the instrument and so to the other part of the circuit. This instrument, which is similar in construction to the ordinary Branly coherer, differs from it only equal conductivity of their surfaces and stops their further deterioration, thus preventing a change in the character of the gas in the space in which they are enclosed. He prefers not to rarefy the atmosphere within the sensitive device, as this has the effect of rendering the former less constant in regard to its dielectric properties, but merely secures an airtight inclosure of the particles and rigorous absence of moisture, which is fatal to satisfactory working.

The normal position of the cylinder c is vertical, and when turned in the manner described, the grains in it are simply shifted from one end to the other; but inasmuch as they always fall through the same space and are subjected to the same agitation they are brought after each operation of the relay to precisely the same electrical condition and offer the same resistance to the flow of the battery current until another impulse from afar reaches the receiving current.

Referring again to Fig. 2, K' K" are two relay magnets conveniently placed in the rear of the propelling engine. One terminal of a battery k" is connected to one end of each of the relay coils, the opposite terminal to the brush J', and the opposite ends of the relay coils to the brush J and to the frame of the instrument, respectively. As a consequence of this arrangement either the relay K' or K" will be energized as the brush J' bears upon the plate j' or j", respectively, or both relays will be inactive while the brush J' bears upon an insulating space between the plates j' and j". While one relay, as K', is energized, its armature closes a circuit through the motor F, which is rotated in a direction to throw the rudder to port. On the other hand, when relay K" is active another circuit through the motor F is closed, which reverses its direction of rotation and shifts the rudder to starboard. These circuits, however, are at the same time utilized for other obvious purposes.

Mr. Tesla informs a "Herald" reporter that using his special apparatus for the production of electrical waves and impulses, he will operate from his laboratory in New York a model which he will exhibit at the Paris Exposition in 1900; from which it may be inferred that he does not expect immediate practical utilization of the idea beyond that with which the New York public has already been made familiar by the electrical exhibition of last May.

The reporters who have been allowed to enter the laboratory state that Mr. Tesla has there a model roughly outlined of a torpedo boat on stocks, the keel of copper plate, with rudder and propeller in the usual positions, and showing two small incandescent lamps on standards. With this he illustrates the operation of the steering gear and of the lights by means of the



FIGS. 2 AND 3.

apparatus for projecting and receiving the electrical [illegible] impulses. No details are given by them of the [illegible] ... C. F. Bra[illegible]

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p. 490 (bottom)

through a connection to the metal keel B' of the vessel. The terminal E' should present a large conducting surface and should be supported as high as practicable on a standard D', which is shown as broken in Fig. 1; but such provisions are not always necessary. It is important to insulate very well the conductor C' in whatever manner it be supported.

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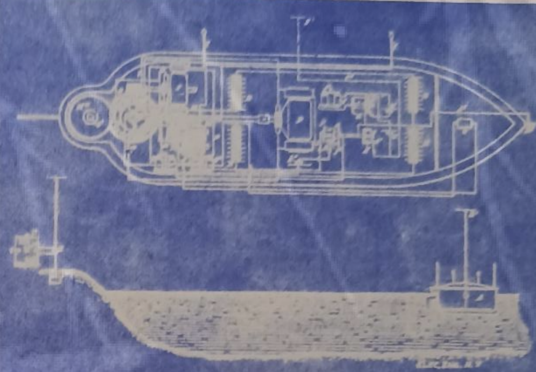
To do away with the defects in the sensitive device, Mr. Tesla makes the particles by a special tool, insuring their equality in size, weight and shape, and they are then uniformly oxidixed by placing them for a given time in an acid solution. This secures



FIGS. 2 AND 3.

apparatus for projecting and receiving the electrical waves or impulses. No details are given by them of the mechanism.

Discussing the subject Prof. C. F. Brackett, of Princeton University, says: "The shortest, most correct and most complete criticism which I can make in reference to this bold boast is that what is new about it is useless, while that which is useful had all been discovered by other scientists long before Tesla made this startling announcement. You will find the whole theory which he has applied in any up-to-date text book. What Tesla has done is simply to make theoretical application, which would prove to be absolutely ridiculous in application of inventions

p. 491

which had already been discovered. There is nothing new about this. The theory is perfect, but the application absurd. So throughout Tesla's whole elaborate scheme, the theory is not at fault, although there is nothing original about it, but the circumstances under which its application would be necessitated are such that the only result would be failure. Do you suppose that in the din of battle it would be possible to put into execution those minute and carefully adjusted mechanical experiments, all of which are presupposed by his theory, which require the quiet of an uninterrupted laboratory to work successfully? Or do you think that the enemy would co-operate with the attack and place their vessels in exactly the correct position to be hit or that they would remain stationary while the torpedo boat approached? His theory would have to assume an affirmative answer in order to be a success, and moreover the torpedo boat would have to be seen from the base of operations in order to direct it. It would be discovered by the doomed vessel long before it reached its destination, and would be exploded on the spot, so how great an advance is this on the present mode of warfare?"

Prof. A. E. Dolbear, of Tufts College, Massachusetts, says: "This last so-called invention of Nikola Tesla's is a very pretentious affair, and it is so incredible that the story is not to be believed until the work is actually done. If Tesla said all that the 'Herald' quotes him as saying, then his whole scheme and his manner of working is unintelligible to me. He even says that 'this power can be exerted at any distance by an agency of so delicate, so impalpable a quality, that I feel I am justified in predicting that the time will come when it can be called into action by the mere exercise of the human will.'

"That is getting a little outside of science, but you will notice that Tesla himself is only predicting that this will come true. There has been no accomplishment. He proposes to do great things, but he does not tell how he is going to do them, and he hasn't done them himself yet.

"The announcement is most amazing, and, coming as it does from Tesla, scientists are all the more chary about accepting it. During the last six years he has made so many startling announcements and has performed so few of his promises that he is getting to be like the man who called 'Wolf! wolf!' until no one listened to him. Mr. Tesla has failed so often before that there is no call to believe these things until he really does them. Meantime, we are all waiting with much patience and without solicitude. We will believe them when they are done."

Regulations at the Paris Exposition.

THE entire space occupied by the Paris Exposition will be considered as a bonded warehouse, and foreign products forwarded to the exposition will enter France through all goods traffic offices. The sender will be required to forward a statement, which must be joined to the goods traffic receipt, and in which must be indicated the nature, kind, weight and origin of the products. All the shipments to the exposition will be subject to the conditions of international goods traffic or ordinary goods traffic, at the option of the parties interested. Shipments made by international or ordinary goods traffic will not undergo examination at the frontier of France. Sealing will be done free,

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Vol. XXVI. NEW YORK, NOVEMBER 17, 1898. No. 550.

Prices for City Arc Lights.

INQUIRY having been made of us as to the new contract for city lighting in Boston and the data upon which it was based, we may say with reference to that interesting and important subject, that the agreement was entered into last August and runs for ten years, as already noted in our columns. It provides for the use of enclosed arc lights of 2,000 c. p. and the scale of rates is as follows:

Number of lights.	Price per night. Cents.	Price per year.
Not less than 2,365 nor more than 2,749	35	$127.75
" " " 2,750 " " " 2,999	34½	125.92
" " " 3,000 " " " 3,249	34	124.10
" " " 3,250 " " " 3,499	33½	122.27
" " " 3,500 " " " 3,749	33	120.45
" " " 3,750 " " " 3,999	32½	118.62
" " " 4,000 " " " 4,249	32	116.80
" " " 4,250 " " " 4,499	31½	114.97
" " " 4,500 " " " 4,479	31	113.15
" " " 4,750 " " " 4,999	30½	111.32
" " " 5,000 " " "	30	109.50

This scale is subject to submission to arbitrators and to revision in favor of the city from time to time, if investigation shows the prices to be capable of reduction, due allowance being made for not less than 7 per cent. for depreciation and 6 per cent. for fixed charges. These arbitrators have the ability to force on the company the adoption of any new system or device that shall have shown itself useful as a means towards the reduction of cost.

This is certainly a notable and remarkable contract, breathing the spirit of equity, and embodying to the full all those modern ideas which regard corporations no longer as bodies of men allied solely for purposes of mutual profit but as servitors of the public protected and fostered only so long as the State can derive direct as well as indirect benefit and recompense as a partner in the concern. Aside from these politico-economic and philosophical points, however, there is some very practical satisfaction in the evidence that the contract was warranted by, if not indeed largely based upon, the report of ex-Mayor N. Matthews, Jr., employed as special counsel by the city to tell it how much it ought to pay for electric lighting. That gentleman made one of his thoroughgoing studies of the question, and reinforced his own conclusions by the advice of acknowledged and disinterested experts. What he informed his successor, the Mayor of Boston, was that the average price per light per annum [illegible] $127.75 for streets and $124.10 for park lights per annum, or when all the differences in local conditions capable of being represented in dollars and cents are taken into account, slightly lower than the cost on a commercial basis of the lights furnished by the municipal plant in Detroit and considerably lower than the cost on a commercial basis of the lights furnished by the municipal plant in Chicago, is very fair to all parties. The prices are considerably higher than the prices charged by the Missouri Edison Co., of St. Louis, and the Cincinnati Edison Co., and slightly higher than those charged in Baltimore by a new competing company for park lights. The summary comes out as follows:

SUMMARY.

City.	Price per light per annum corrected for conditions obtaining in Boston.
Boston (average price)	$127.25
Detroit municipal plant (on commercial basis)	134.57
Chicago municipal plant (on commercial basis)	154.80
Chicago (company) (underground contract)	129.20
Chicago (company) (overhead contracts)	128.43
St. Louis	99.67
Cincinnati	110.89
Baltimore, street lights	154.68
Baltimore, park lights	122.68
Philadelphia (average price)	143.33
New York	139.90

Of course, in preference to this equitable and surely satisfactory contract, Boston might have put in its own plant after going through the conditions required by law, but it has most wisely decided not to venture into that uncertain investment. It finds warrant for such decision in some figures compiled recently by Alderman Wesley Sears, of Jackson, Mich., and presented prominently in the October issue of "City Government," a journal which has certainly no bias towards private companies. Mr. Sears tried hard to get all the data he could about municipal plants, and he gives a lot of it, but the comments that came in are even more interesting and striking than the figures. For example, Bloomington, Ill., says: "We figure no depreciation; neither do we figure interest, because," etc. What a fool's paradise those city officials must live in! Crawfordsville, Ind., says: "We do own our light, but if we did not, we would not, for in my opinion it will bankrupt us." Michigan City, Ind., says: "The time our city owned the electric light plant, it was run in connection with our waterworks. It was run very unsatisfactorily, and the plant had run down. Our council thought it best to sell. We got $3,000 for same. Think original cost was $8,000." And so it goes.

Mr. Tesla and the Czar.

THE personality of Mr. Tesla is one of the most fascinating in the field of modern invention, and his work is such as to command the interest of both the lay and the scientific public whenever he chooses to give details of his investigations and researches. If he had never done more than develop the theory and practice of the multiphase system, his life would have been useful above the ordinary; and even should it happen that none of his other ideas ever get into practical shape, his discoveries in electricity must always be regarded as important. We cannot number ourselves among those who, like the distinguished scientists, Profs. Brackett and Dolbear, quoted in our columns this week, are impatient with his tendency to let imagination outrun achievement and who virtually class him as a humbug. Mr. Tesla fools himself, if he fools anybody, when he launches forth

into the dazzling theories and speculations associated with his name. That he should desire to benefit the human race in ways now unknown, and should avow out loud belief in his capacity to do so, is surely not discreditable, any more than it is unworthy in the head of his own poetic Slavic race to propose the disarmament of the world. Granted that there will still be wars, and granted that all these wonderful visions of new arts in peace do not fructify without the work of a score of later geniuses, why find fault either with the Czar or with Mr. Tesla? Their aims appear wholly noble, their thoughts are beautiful, and if they fail, as they probably will in some material and vital respects, the world is certainly none the worse off for what they actually accomplish.

Just of late Mr. Tesla has been giving publicity to some of his newest work, and it is peculiarly interesting. We should have been glad, personally, to see him finish up some of the many other things that have occupied his energies these ten years past, but none of which now claim any place. For example, his "oscillator," or combination of generator and steam engine, which was to wipe out all other methods of power generation and reduce vastly the cost of power, by steam and electric economies. The very name is now bestowed by Mr. Tesla on another piece of apparatus, and though illustrated in detail and brought before the Chicago Electrical Congress in 1893, the "oscillator" of the original brand is, for aught the public knows, in the scrap heap. Yet it was a lovely invention, of infinite possibilities. We can only regret its neglect and oblivion, but if Mr. Tesla has other things more appealing to his mind for the present, that is his own business.

Of late also Mr. Tesla has brought forward another plan of power generation and transmission. At one period he expressed his belief in ability to disturb the earth's charge and thus send currents through the earth. That does not appear to be so feasible or attractive now as the idea of using the upper strata of the air which he says have a very superior conductivity. He would tether up aloft balloons in those strata and deliver to them large quantities of current at such high potential that it would travel economically across the space without wires, say from Niagara Falls to Paris. By this facile distribution of water power, coal and steam would become unnecessary to industry. The new plan may explain why Mr. Tesla has abandoned his old steam oscillator. It is earnestly to be hoped that this novel idea will prove workable. Balloons were a dismal failure in our late war, but that is no criterion, and Mr. Tesla may have some superior gas for inflation and sustentation purposes. It will be remembered that Mr. Marconi has already telegraphed from balloon to balloon, without wires, a distance of over twenty miles, thus proving in advance the tenability of Mr. Tesla's proposition.

The tremendous hold that war has taken upon the public mind is shown by the fact that even a genius of Mr. Tesla's independence is compelled to invention in that field. A patent issued to him last week intimates that he believes that torpedos and torpedo boats which were so utterly useless and unmanageable in the late conflict with Spain can be made more valuable if controlled entirely from shore, by a Navy Board, and without any crew. Last spring the ability to explode floating torpedos under ships from a distance without any wires was brilliantly demonstrated at Madison Square Garden several times a day for a month. Taking that idea, Mr. Tesla has applied the same principle to the electro-mechanical steering of torpedos, just as it is now done with several types, but, of course, in his case, without the intervening wires from shore. He is very sanguine that this will stop war, and we pray heartily that it may. The article or patent digest we print in this issue on the subject suggests improvements of his on existing apparatus that may render it, in spite of its great delicacy, able to evade jarring and jolting, the perils of the open sea, the defensive network crinolines around the ships, the concussions of great guns, and the intentional explosion of defenses placed in its way thus to derange and negative its operation. During the late war, apparatus far less sensitive than coherers was rendered useless by the firing of finished lecture two years ago before the New York Academy of Sciences, which has never found its way into print, but of which the opening passages indicated the covering of the same ground. We trust that the data given by Mr. Tesla may stimulate our medical friends to greater employment of electricity. It is unfortunately true that disastrous results from injudicious use by some of them of Prof. Röntgen's great discovery of the X-ray have made medical men fight shy of handling electricity themselves lately, and we do not know whether Mr. Tesla's experiments will altogether reassure them, so striking and farreaching are they. But the saving of human life is a sacred thing. Every means and instrumentality must be tried by the surgeon and the physician, and it is devoutly to be hoped that having stopped the slaughter due to war Mr. Tesla will revert at some time to this brilliant paper and give the doctors apparatus that will help prevent the slaughter due to accident and disease.

It is not our desire to pose as apologists or publicists for Mr. Tesla. He needs no assistance of that kind; and so long as he commands freely whole pages of the Sunday papers, for which Mr. Wanamaker pays gladly his thousands of dollars, the technical and scientific journals have, indeed, little to do with the matter. All we wish to say is that it is not fair to condemn, as so many do, Mr. Tesla as visionary and impractical. No man has finished his work till he is dead, and even then there are long, long centuries in which his ideas can prove themselves true. The visionaries are thus often, in the end, the most sordid of realists—something Mr. Tesla will never be.

A Timely Warning.

IN our columns last week we printed an abstract of a very interesting paper read before the International Association of Fire Engineers, at St. Louis, by Capt. W. Brophy on the serious fire dangers of apparatus for showing animated pictures, which recalled to our minds the terrible Paris calamity of a few years ago. That this warning of Capt. Brophy, who has made the subject of fire protection a life study, is a timely one and deserving of immediate action on the part of local authorities, was evidenced last week by a fire in Huber's Museum and Theater, New York City, caused by the burning out of a fuse in a cinematograph. At the time the fire was started, about two thousand persons were in the building and it seems a miracle that no one was seriously hurt in the panic which resulted and which quickly emptied the house. It was a serious lesson, however, for the Board of Fire Underwriters, who should insist, as Capt. Brophy stated, that in the wiring of these machines and their construction the rules in the "National Code" must be complied with.

THE recent treatment of their employés by many companies during the war with Spain bore evidence, if it were needed, that there are corporations with souls. Such instances of patriotism and generosity were numerous. In the case of the Chicago Edison Co. not only were the men who went to the front carried on the pay rolls, but when they came back the president—an Englishman, at that—gave them a rousing banquet at his own expense. Now, during the yellow fever troubles down South, we note corresponding action on the part of the Postal Telegraph Co., which has made personal to itself the welfare of every one of its employés stricken down at the post of duty and has provided all medical aid and every needed comfort. It has, we understand, gone even further than [illegible] record of fact will suffice to show how humane [illegible] ments pervading the management. The company [illegible] publicity in this respect, but that simply adds [illegible] action. So shines a good deed in this [illegible]

b-487

economies. The very name is now bestowed by Mr. Tesla on another piece of apparatus, and though illustrated in detail and brought before the Chicago Electrical Congress in 1893, the "oscillator" of the original brand is, for aught the public knows, in the scrap heap. Yet it was a lovely invention, of infinite possibilities. We can only regret its neglect and oblivion, but if Mr. Tesla has other things more appealing to his mind for the present, that is his own business.

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While all these curious things are "in the air," so to speak, it is a distinct pleasure to be able to print, as we do in this issue, Mr. Tesla's able and thoughtful paper read before the Buffalo meeting of the American Electro-Therapeutic Association. It compensates for the disappointment experienced from his un-

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Telephone: 1323 Cortlandt. Cable Address: [illegible]

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Vol. XXVI. NEW YORK, NOVEMBER 17, 1898. No. 550.

Prices for City Arc Lights.

INQUIRY having been made of us as to the new contract for city lighting in Boston and the data upon which it was based, we may say with reference to that interesting and important subject, that the agreement was entered into last August and runs for ten years, as already noted in our columns. It provides for the use of enclosed arc lights of 2,000 c. p. and the scale of rates is as follows:

Number of lights.	Price per night. Cents.	Price. per year.
Not less than 2,365 nor more than 2,749	35	$127.75
" " " 2,750 " " " 2,999	34½	125.92
" " " 3,000 " " " 3,249	34	124.10
" " " 3,250 " " " 3,499	33½	122.27
" " " 3,500 " " " 3,749	33	120.45
" " " 3,750 " " " 3,999	32½	118.62
" " " 4,000 " " " 4,249	32	116.80
" " " 4,250 " " " 4,499	31½	114.97
" " " 4,500 " " " 4,479	31	113.15
" " " 4,750 " " " 4,999	30½	111.32
" " " 5,000 " " "	30	109.50

This scale is subject to submission to arbitrators and to revision in favor of the city from time to time, if investigation shows the prices to be capable of reduction, due allowance being made for not less than 7 per cent. for depreciation and 6 per cent. for fixed charges. These arbitrators have the ability to force on the company the adoption of any new system or device that shall have shown itself useful as a means towards the reduction of cost.

This is certainly a notable and remarkable contract, breathing the spirit of equity, and embodying to the full all those modern ideas which regard corporations no longer as bodies of men allied solely for purposes of mutual profit but as servitors of the public protected and fostered only so long as the State can derive direct as well as indirect benefit and recompense as a partner in the concern. Aside from these politico-economic and philosophical points, however, there is some very practical satisfaction in the evidence that the contract was warranted by, if not indeed largely based upon, the report of ex-Mayor N. Matthews, Jr., employed as special counsel by the city to tell it how much it ought to pay for electric lighting. That gentleman made one of his thoroughgoing studies of the question, and reinforced his own conclusions by the advice of acknowledged and disinterested experts. What he informed his successor, the Mayor of Boston, was that the average price per light per annum [illegible] for street and $124.10 for park lights per annum [illegible] differences in local conditions [illegible] dollars and cents are taken into [illegible] cost on a commercial basis of the [illegible] municipal plant in Detroit and [illegible] on a commercial basis of [illegible] municipal plant in Chicago, is very [illegible] are considerably higher than the [illegible] Edison Co., of St. Louis, and [illegible] slightly higher than those charged in [illegible] peting company for park lights. [illegible] follows:

SUMMARY.

City	
Boston (average price)	[illegible]
Detroit municipal plant (on commercial basis)	[illegible]
Chicago municipal plant (on commercial basis)	[illegible]
Chicago (company) (underground contract)	[illegible]
Chicago (company) (overhead contract)	[illegible]
St. Louis	[illegible]
Cincinnati	[illegible]
Baltimore, street lights	[illegible]
Baltimore, park lights	[illegible]
Philadelphia (average price)	[illegible]
New York	[illegible]

Of course, in preference to this equitable and surely satisfactory contract, Boston might have put in its own plant after going through the conditions required by law, but it has most wisely decided not to venture into that uncertain investment. It finds warrant for such decision in some figures compiled recently by Alderman Wesley Sears, of Jackson, Mich., and presented prominently in the October issue of "City Government," a journal which has certainly no bias towards private companies. Mr. Sears tried hard to get all the data he could about municipal plants, and he gives a lot of it, but the comments that came in are even more interesting and striking than the figures. For example, Bloomington, Ill., says: "We figure no depreciation; neither do we figure interest, because," etc. What a fool's paradise those city officials must live in! Crawfordsville, Ind., says: "We do own our light, but if we did not, we would not, for in my opinion it will bankrupt us." Michigan City, Ind., says: "The time our city owned the electric light plant, it was run in connection with our waterworks. It was run very unsatisfactorily, and the plant had run down. Our council thought it best to sell. We got $3,000 for same. Think original cost was $8,000." And so it goes.

Mr. Tesla and the Czar.

THE personality of Mr. Tesla is one of the most fascinating in the field of modern invention, and his work is such as to command the interest of both the lay and the scientific public whenever he chooses to give details of his investigations and researches. If he had never done more than develop the theory and practice of the multiphase system, his life would have been useful above the ordinary; and even should it happen that none of his other ideas ever get into practical shape, his discoveries in electricity must always be regarded as important. We cannot number ourselves among those who, like the distinguished scientists, Profs. Brackett and Dolbear, quoted in our columns this week, are impatient with his tendency to let imagination outrun achievement and who virtually class him as a humbug. Mr. Tesla fools himself, if he fools anybody, when he launches forth

THE

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Vol. XXVI. NEW YORK, NOVEMBER 24, 1898. No. 551.

Mr. Tesla to His Friends.

New York, Nov. 18, 1898.
46 and 48 East Houston St.

Editor of The Electrical Engineer, 120 Liberty St., New York City.

Sir—By publishing in your columns of Nov. 17 my recent contribution to the Electro-Therapeutic Society you have finally succeeded—after many vain attempts made during a number of years—in causing me a serious injury. It has cost me great pains to write that paper, and I have expected to see it appear among other dignified contributions of its kind, and, I confess, the wound is deep. But you will have no opportunity for inflicting a similar one, as I propose to take better care of my papers in the future. In what manner you have secured this one in advance of other electrical periodicals who had an equal right to the same, rests with the secretary of the society to explain.

Your editorial comment would not concern me in the least, were it not my duty to take note of it. On more than one occasion you have offended me, but in my qualities both as Christian and philosopher I have always forgiven you and only pitied you for your errors. This time, though, your offence is graver than the previous ones, for you have dared to cast a shadow on my honor.

No doubt you must have in your possession, from the illustrious men whom you quote, tangible proofs in support of your statement reflecting on my honesty. Being a bearer of great honors from a number of American universities, it is my duty, in view of the slur thus cast upon them, to exact from you that in your next issue you produce these, together with this letter, which in justice to myself, I am forwarding to other electrical journals. In the absence of such proofs, which would put me in the position to seek redress elsewhere, I require that, together with the preceding, you publish instead a complete and humble apology for your insulting remark which reflects on me as well as on those who honor me.

On this condition I will again forgive you; but I would advise you to limit yourself in your future attacks to statements for which you are not liable to be punished by law.

N. TESLA.

His Friends to Mr. Tesla.

ONE of the foremost electrical inventors of this co whose name is known around the world, has been enough to say that The Electrical Engineer made Mr. Tesla. This is an attribution that we naturally put aside, for it is a man's own work that makes or unmakes him, but we do plead guilty to the fact that for these ten years past we have done whatever mortals could do to bring Mr. Tesla forward and secure for him the recognition that was duly his. Not only in the columns of this and other journals, but in magazines and books we have striven with all the ability we possessed to explain Mr. Tesla's ideas. The record is before all men. If there is a line or a word in it that seeks to do Mr. Tesla "serious injury," we demand its production by him. The man, whoever he be, who says we have ever in word or deed or thought tried to do Mr. Tesla any sort of injury, lies.

Within the last year or two Mr. Tesla has, it seems to us, gone far beyond the possible in the ideas he has put forth, and he has to-day behind him a long trail of beautiful but unfinished inventions. By mild criticism and milder banter, not being able to lend Mr. Tesla the cordial support of earlier years of real achievement, we have only very lately endeavored to express our doubts and to urge him to the completion of some one of the many desirable or novel things promised. We believe this to be true friendship.

For example, take Mr. Tesla's latest and furthest enlargement of his newest idea, as presented by him in a signed letter in the New York "Sun," of Nov. 21, unfolding his plan to dispense with artillery of the present type. At this moment we have space only for the following passage:

"We shall be able, availing ourselves of this advance, TO SEND A PROJECTILE, at much greater distance, IT WILL NOT BE LIMITED IN ANY WAY BY WEIGHT or amount of explosive charge, we shall be able to submerge it at command, TO ARREST IT IN ITS FLIGHT AND CALL IT BACK, and to send it out again and explode it at will, and, more than this, IT WILL NEVER MAKE A MISS."

When we are expected, wide awake and in our sober senses, to accept in silence such an utterance as that quoted above or that which describes as "a possibility" the operation of a distant torpedo boat by the mere exercise of the will, we refuse point blank and we are willing to face the consequences. Our past admiration of Mr. Tesla's real, tangible work is on record, and stands; but we draw the line at such things as these. We are sorry Mr. Tesla feels it so keenly, but we cannot help it.

Now, as to the specific points raised in the above letter, which Mr. Tesla certainly would not have written had he been well advised. As to the manner in which we came to print Mr. Tesla's paper, the two letters herewith speak for themselves.

The American Electro-Therapeutic Association.
Dr. Charles R. Dickson, Ex-President.
296 Sherbourne St.
Toronto, Canada, Sept. 26, 1898.

T. Commerford Martin, Esq., 120 Liberty St., New York.

Dear Sir—I was quite surprised to hear on Saturday last from my friend, Dr. Robert Newman, of New York, that the editors of The Electrical Engineer had received no notices of the meeting of our association; I understood that the secretary had sent them. However, in case you might find space to say something of us, I have patched up an article drawn from various sources giving full particulars, which you can cut down to the desired dimensions. I fully appreciate all that you have done for the association in the past, or would not go to this trouble. I also send you a copy of the programme and of hand-book. In regard to latter, I am very sorry that the Buffalo committee had to retain for such a long time the electro of Mr. Tesla which you were so kind as to loan to them through Dr. Newman

I have to thank you very sincerely for the loan of the electro, and hope that it reached you in good condition.

Wishing your esteemed journal continued and increasing success, very truly yours, CHARLES R. DICKSON.

The American Electro-Therapeutic Association.
Dr. Robert Newman, Chairman.
64 West 36th St.
New York City, Oct. 20, 1898.

Messrs. T. C. Martin and J. Wetzler.

Messrs. Editors—We have now the necessary vote for you publishing Tesla's paper in The Electrical Engineer, you lending us the cuts in proper size for our transactions.

The pages of our book are 7½ by 5 inches—if our secretary is not dilatory, you will receive the mss. and illustrations at once. Will call soon. Yours most truly, ROBERT NEWMAN.

These show our relations with a deserving association and our efforts to assist its work. We may add as a matter of fact, for which, if necessary, the proofs will be presented, that before printing the paper, we sent Dr. Newman to technical publishers, who refused to print the matter in book form because there was not, in their estimation, sufficient demand for it among scientific men. Failing this, we were undoubtedly glad to give it a place in our pages, as it struck us as good "copy."

We venture also to direct attention to the dates of the Dickson and Newman letters, one Sept. 26 and the other Oct. 20. The Tesla paper was read on Sept. 15 and appeared in our columns Nov. 17. Does this gap of over two months between reading and publication justify Mr. Tesla's insinuation that we took swift and mean advantage of him and of our contemporaries? Will anyone produce a letter to show that anyone of our contemporaries ever took the slightest interest in the Tesla paper or even asked for it? If such letters exist, now is the time to produce them. The paper was given to The Electrical Engineer because this journal takes a deep interest in the advance of electro-therapists and has a wide circulation among them, and according to universal custom, the paper once read became the property of the association to deal with as it chose. That, without any particular effort, we should have secured a "scoop"—to use the slang of journalism—is nothing to be ashamed of; we rather glory in it, for whatever it is worth.

It will be noted that we placed freely at the disposal of the association a portrait block of Mr. Tesla which we value highly. We were anxious, however, to do him honor in this way, and loaned the original. Since that time, we have loaned it, without charge, to Mr. Belford, of "Success," in whose November issue it appears by our courtesy; and we have within the past week placed it at the disposal of another publishing house. Perhaps these are the attempts to do him an injury about which Mr. Tesla has so unfortunately allowed himself to be persuaded.

Now as to the very depreciatory quotations from the distinguished scientists, Profs. Brackett and Dolbear. The passage from Prof. Brackett appeared in the New York "Herald" of Nov. 9. That from Prof. Dolbear appeared in the New York "Herald" of Nov. 10. They had not been contradicted or withdrawn when we called attention to them and objected to them. One of our electrical contemporaries last week quoted them both like ourselves, but said it was inclined to agree with Prof. Dolbear. We now beg to call Mr. Tesla's attention to the subjoined dispatches from both scientists, and would say that having already expressed dissent from the views of both Profs. Brackett and Dolbear, we do not see how it concerns us any further.

(Press Telegram.)

Princeton, N. J., Nov. 20, 1898.

T. C. Martin, Editor of The Electrical Engineer, New York.

Some of the language on pages 490 and 491 of The Electrical Engineer of Nov. 17, purporting to be quoted from me, is a fairly correct reproduction of what I said to a "Herald" reporter in reply to his question as to the probable practicability of Mr. Tesla's device for the abolishing war already presented in the "Herald," a copy of which he showed me.

In the language which you quote, there is much confusion and inaccuracy, due to the fact that the reporter took no notes of what I said, but trusted his memory.

No subject other than that proposed, viz.: Is the proposed plan practicable, was discussed. C. F. BRACKETT.

North Cambridge, Mass., Nov. 21.

The Electrical Engineer, New York.

Letter received this morning. The "Herald" report was substantially accurate. I will write more to you presently.

A. E. DOLBEAR.

"Greatest Discovery of the Age."

Mr. H. W. Phillips, in the "Criterion" of Nov. 19, has an illustrated interview with Mr. Tesla, whom he quotes as follows in regard to his use of the coherer as a relay for steering dirigible torpedoes: "I think that it is the greatest discovery of the age. There is something artistic—an appeal to the imagination—in it that the telephone, phonograph and other fine inventions lack." In reply to an inquiry as to his ability to operate the coherer by an effort of the will merely, Mr. Tesla said to Mr. Phillips: "I have no evidence to support it, but I have a perfect right to state it—understand me—as a possibility—no more." Mr. Tesla also remarked: "Had I nothing else to show for a lifework, this would put the laurels of everlasting fame on my head."

The Evolution of the Surface Contact Railway.

THE sudden, swift and tremendous development of the open conduit railway system must have arrested the attention of every one who takes notice of electro-mechanical advance. Up to within the last year or two it seemed as though that method of traction would not operate successfully and economically in our American cities. Every trial resulted in utter failure in regard to convincing street railway managers that it was what they wanted. Now a change has come, and in New York nothing but the open conduit trolley has for the present the ghost of a chance; while many other cities bid fair soon to fall in line. Having fought hard for the overhead trolley, we can say that we welcome heartily this wonderful broadening out of the traction art, enabling electricity to capture the metropolis that was so long denied to it.

But is the end yet? Why need a conduit be open? Why must there be a couple of extra gutters in the street with bare exposed electrical conductors in them? We believe firmly that there is no final reason; but that the next step is some form of sealed conduit, or surface contact, system. Every indication points that way, and it is for this reason that we are glad to give space to the paper on this subject by Mr. E. H. Johnson, read last week before the New York Electrical Society. It must be remembered that he does not stand alone in his advocacy of the new departure. Both the Westinghouse and the General Electric companies have adopted sealed conduit systems, and reports of others come thickly from across the Atlantic. Such signs cannot well be mistaken.

As to the merits of the Johnson-Lundell system, it is hardly within our province to pronounce a judgment yet, but we wish it the fullest success. It has a great many good points, and it has behind it a man who despite the ardor of his enthusiasm has never yet backed a failure. Mr. Johnson ties to realities and builds up concrete successes, and it will be strange indeed if in the near future he does not see all his hopes as to surface contact railways realized to the fullest degree.

A New Electric Railway on Manhattan Island.

A certificate incorporating the Fort George Extension Railway Company, of New York City, with a capital of $10,000, was filed with the Secretary of State on Nov. 17. The company purposes to operate an electrical surface road from 172d to 185th street, on Eleventh avenue. Its directors are M. G. Starrett, W. P. Plummer, John Lambden, Andrew Loughlin, D. W. Patterson and Harry Hartwell, of New York City; John Kerr and Charles E. Corby, of Brooklyn, and H. A. Himely, of Far Rockaway.

plants, and to make them blossom as the rose, will be watched with the utmost interest and good will, and should prove that electricity not only abhors a desert, but abolishes it.

Mr. Tesla's New Theory of Artificial Light.

EVER since Mr. Tesla practically finished his multiphase motor work, now more than ten years ago, he is understood to have devoted much of his time to experimental work in the domain of electric lighting. His first attempts led him in the direction of the vacuum tube and his brilliant lectures on that subject, both here and abroad, must still be fresh in the minds of many of our readers. But even in those lectures Mr. Tesla devoted considerable space to the discussion of the employment of solid, refractory materials as light giving media under the influence of high frequency currents. It would seem, however, that of late Mr. Tesla has greatly modified his views as to what is a sine qua non in a successful electric illuminant. At least we are led to this belief after reading an interview had with him by Mr. Charles Culver Johnson, appearing in the "Philadelphia Press." We must confess at the outset that we are unable to follow the interviewer at all points, but we gather in general that Mr. Tesla has come to the conclusion that electricians have all been on the wrong track in the past in working on so-called non-refractory or heat proof materials as light giving bodies. There are, Mr. Tesla says, a few bodies which for a time seem to be indifferent to heat, but he has found that not one of them will endure a continuous strain. In this new discovery, we are told, vibrations play a most important part, Mr. Tesla having succeeded in obtaining more perfect control of the more rapid vibrations of light waves. Carbon is not employed as the light giver. As to the nature of the force employed the interviewer quotes Mr. Tesla as saying that he "will form an electric circuit and then with a file reduce the thickness of the wire a sixteenth of an inch and double the force of the current." The details of Mr. Tesla's work in this direction are unfortunately lacking, but Mr. Tesla promises to prepare a paper on the subject, "which he will read presently to a few scientific friends." Failing full details the information thus far vouchsafed is insufficient to permit of much comment, but we are glad to know that we may so soon expect a promised advance in electric lighting. All such work as this, or, in older directions, such as that on the Nernst lamp, is worthy of fullest encouragement.

Electric Stairways.


GRAB
A BEER
BY DRAFT
VIEUX
CARRÉ
ABSINTHE
SUPÉRIEURE
120 PROOF
60% ALC/VOL